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A Notable Power Transmission.

In these days it is unusual to find a power trasmission plant which includes startling features of novelty, and it is therefore interesting to note in the Kern River No. 1 plant of the Los Angeles Edison Co. engineering of an exceptionally advanced type. This plant was described in the last two issues of this journal. The Los Angeles region was the scene of the earliest work on this continent in modern power transmission and the engineers of the Coast have consistently kept on the firing line of progress ever since. The first plants of the Los Angeles Edison Co. were in the region of the original Redlands system and took their power from the streams in the southern canyons of the Sierras that sweep westward toward the Pacific. Most of the available powers here have now been developed and in seeking an increase of output the engineers cast their eyes northward. The present great plant is therefore on the Kern River, which is a tributary of the San Joaquin clear across the mountains and drawing its water from an entirely distinct watershed more heavily wooded and of somewhat different characteristics. The result will be that the fluctuations in the total supply of power will be decreased, and the system will be the more reliable. The great network in the northern part of the Golden State has somewhat of the same characteristics, the De Sabla power house, for instance, drawing its water from a slope quite different in its character from that feeding the Electra powerhouse, yet there is probably no case where there is quite such independence in the water supply as in the Los Angeles system.

Another striking characteristic of the Kern River plant is the very extensive and deliberate use of tunnels for the hydraulic works. This was partly suggested by the topography, but more probably by the extent of the works in length and capacity. Most of the California plants are fed by timber flumes, which follow the earlier practice of the ditch companies. Others with shorter distances to cover use steel pipe throughout. Here the main part of the conduit is in tunnels lined with concrete, and what is still more striking the pressure pipe above the powerhouse is itself a steel-lined concreted tunnel practically clear down to the penstocks. Here again, topography had something to do with the matter, but the innovation is a striking one nevertheless and it certainly simplifies the carrying of the large volume of water since the steel is backed by the concrete and does not have the serious difficulties that would have been involved in a plain steel pipe of the requisite dimensions. The tunnel construction is undeniably expensive in first cost, yet the upkeep should be low enough to compensate in large measure for the fixed charges and the chance of a breakdown is certainly greatly diminished. A system like that of the Edison Co. must be considered as a whole and while the other plants act as a partial relay this 20,000-kw. installation is so much the most important one for future work that it was certainly good policy to take no chances with the hydraulic works.

In the design of the power plant itself, perhaps the most striking feature is the size of the units. The impulse wheels are probably by far the most powerful single units ever produced and the generators are the largest ever coupled to impulse wheels, especially when overload capacity is taken into account. The generators themselves are for 50 cycles, the frequency of the original Redlands plant and of the later plants near it. Whether any lower frequency than this might be desirable at greater distances of transmission is an open question, but certainly there are no signs yet that even the long 60 cycle lines further north have been at all inconvenienced by the frequency. The voltage at present in the Kern River plant is 60,000, although the system is planned for the use of 75,000 volts later. In the climate of California there is no reason to hesitate in using it after the lines have been worked into good running condition. One of the interesting details in construction work to which attention should be called was the installation of a temporary hydro-electric plant to supply power for driving the tunnels and doing other preliminary work, and even more characteristic of Pacific Coast enterprise was the installation of an automobile trucking line for carrying cement and other material up to the works from the railroad. Automobiles have been used in construction work times enough, but this particular operation is beautifully characteristic of the way they do things on the Coast, where conservatism is not counted a virtue in and of itself, and where standards are held precious only so long as they remain useful. It would be well if every Eastern engineer had to do a turn of duty in the Rockies and westward just to get shaken out of some of the hidebound precedents that infest Eastern practice. The Kern River system is now only at the start; there is room for other plants when the need for more power arises, and certainly the Los Angeles Edison Co. is to be congratulated on the daring and effective work it has already accomplished.

Power-Plant Machine Shops.

The development of power plants of very large capacity within the last few years has created many new problems in design and operation. The question of maintenance of equipment with respect to continuous service is present in all commercial plants, but as the size of installations increases, the problem of local repairs assumes an importance which cannot be overlooked in any well-planned station. Repairs are frequent in small installations, but in a plant of from 10,000 to 20,000 kw. rating and upward, there is practically a continuous necessity for the pushing on of such work. The main generating units may not require the attention which is proportionally expended on smaller machines, but the auxiliaries and piping, valves, traps and other fittings in very large plants are employed on such a large scale that ample provision should be made for their maintenance, if possible, on the premises.

The power-plant machine shop is the natural outcome of the foregoing conditions, and it is interesting to note the way in which the small shop is coming into its proper place in the design of the larger plants. The comparatively new station of the Suburban Gas & Electric Company at Revere, Mass., illustrates this tendency in plants of moderate size, where the custom is to pump-drive the necessary machine tools by a small motor; and the Port Morris station of the New York Central R. R., with its individually operated set of machine tools located on a special section of the turbine room gallery, shows the importance of the local shop in the exacting service of a very large plant. Formerly a simple workbench equipped with a vise and such tools as the operating staff might personally own and be willing to keep at hand sufficed for the machine shop of a power station, and there is no doubt that some ingenious and handy repair jobs were executed in this way. The conditions are more exacting in these days, and it is a source of satisfaction that progressive designing engineers are appreciating the economy of well-lighted and decently equipped repair shops in the important stations. This kind of maintenance work has yet to be put on a firm basis, however, for until very recently the minor plant repairs have been handled by pretty much any one on the engine room staff. The cost of these repairs has seldom been figured, records of the shop work performed have been few, and the actual money value of a good shop inside the power house walls has been left very much to the imagination.

It should be clear enough by this time that a simple shop with a few tools driven by power is desirable and necessary to the best results in almost any plant, no matter how small it is. The operating engineers usually possess considerable mechanical skill, and few stations are without the services of at least one man with special aptitude for putting together simple, home-made rigs and combinations of apparatus which will save the plant good money every month when installed. To encourage this kind of inventive ability is worth a great deal more than the low fixed charges on a lathe, drill, shaper and emery wheel with a small motor drive for the group. Even in very large plants there should be facilities for the working out of special ideas aiming toward securing lower fuel and water bills, reduced repairs and increased flexibility of operation. In the latter case, however, it is probable that the shop work will be so important that one or more machinists will be continuously on duty, and the exactions of taking care of generating units of very large cost may leave little time for the development of special rigs. Unless meritorious ideas can be tried out, there is a defeating of its own ends in part by the power plant shop, and it should always be realized that a certain amount of research along economical lines is quite as important as the mere routine grinding of valves, straightening of stems, adjusting packing, and assembly of pipe fittings which so often absorbs the shop tools' activity. Such a shop can do valuable work in the assembly of a new plant, and sometimes for months after it is started the shop will greatly facilitate the final adjustments of equipment. Direct connected tools with variable speed control are most advantageous in the face of their cost, in large stations, but even the small plant with group drive deserves better than hand facilities for the quicker and lighter repairs.

Engineering Office Libraries.

One of the most instructive recent papers for engineers is that by Mr. Lee, librarian of Stone & Webster, on the library department of that firm's organization. An abstract of it appears elsewhere in this issue, from which it will be seen that the department is considerably more than a library, for it really is an information bureau, answering questions not only by research in books and journals, but also by correspondence with those outside and inside the organization likely to know what is desired by the inquirer. It is a recent development and probably ten years hence will be strengthened along several lines which at present are but dimly recognized, but the department to-day is a concrete demonstration of the important part printed information plays in the actual business work of a large engineering organization. The day has gone by when a few school books will answer the requirements of such an office. The time lost in hunting for information or in working out problems that somebody has already solved represents a considerable financial loss, which it is the purpose of this library department to save.

It will be noticed that a large part of the library consists of documents, which is naturally the case with such a business as that of Stone & Webster. Apart from these papers, such documents might well include all the results of minor investigations and experiments made practically all the time in engineering offices of much size. Any item of engineering information, jotted down on a sheet of appropriate size, is just as suitable for preservation in a real working library as a three-volume treatise. Probably the lack of any system for filing such notes is the only reason they are not kept more often. Most engineers have attempted to preserve short notes in manuscript books, only to give up the practice when the trouble of writing them out and of finding them again has been discovered by experience. In consequence, the same man often has to hunt up information on a subject several times, just because it is not made permanently available when found the first time. Probably the time lost in searching for it once is trifling, but when that loss is multiplied several-fold, the total is worth considering. Moreover, in a large office, the chances are pretty fair that a good many people will repeatedly have occasion to refer to certain classes of information, so that a standing order might properly be posted requiring all information gathered in office time to be noted for filing in the library. Incidentally, it may be added, information likely to be generally useful and not of the nature of trade or professional secrets, might be sent to class journals, as is now the custom quite generally in mechanical engineering, although not in civil engineering branches.

It will be evident from a consideration of Mr. Lee's paper that the secret of usefulness of such a business library is its arrangement and indexing for immediate availability. It is this feature of the work that is most troublesome to the engineer and often proves hopeless to a trained librarian without engineering education. The engineer is likely to regard many of the minor details of library work as mere fussiness, and consequently his own system, which lacks them, is likely to break down as soon as it is given a good trial. The trained library assistant, who believes that all knowledge can be classified by the decimal system, is thrown into confusion by the discovery that there are more than ten equally important sub-divisions of some engineering subjects. A decimal classification can be worked out which will probably give satisfaction, when used by people trained in its system; the experience at the Mechanical Engineering Department of the University of Illinois is an indication of this. On the other hand, the importance of a geographical classification is very evident in a business office, as Mr. Lee points out in his paper. It is safe to say that a business man consulting the bound volumes of any journal for information regarding the details of a power plant in St. Louis will look in the index for the name of the city rather than under "power plant," yet indexing geographically is considered crude by most trained librarians. Before a good classification for an engineering office library is adopted, it is therefore desirable for the owners to determine just what they wish to index and for the librarian to cast off all prejudices and learn what questions he will be asked to answer. It may happen that the decimal classification will prove best, or the geographical, or one which is arranged by letters instead of numbers, so as to avoid the limitations of the decimal notation. Time spent in a thorough study of indexing before beginning the library arrangement is warranted by the vital importance of the subject. If the work is properly done and the library skilfully conducted in accordance with the system thus developed, the result will be to make readily available the information gathered by the office in its business and all the contents of class journals, trade catalogues and books. The command of such resources is worth a considerable sum in many offices.

The library managed in this manner is particularly useful in securing the best results from the valuable contents of class journals. The librarian examines each publication carefully as soon as it is received, and any information of immediate concern to the business of the office is brought to the attention of the man who is in charge of the subject. Even in offices which do not maintain a library, it is often customary to have somebody examine all such publications as they are received, for whatever information of immediate interest they may contain. Where a library organization is maintained, however, this examination is more complete, and articles likely to be of permanent value are indexed according to the library classification, thus making it unnecessary to refer in many cases to the indexes of the volumes themselves, which is a tedious and often unsuccessful method of search. Attention is particularly called to this point, because many offices are doubtless already spending a considerable part of the sum needed for pretty fair library work on an examination of journals and trade publications for temporary purposes only. Whether it is best to issue a regular bulletin of notes regarding the contents of class journals, as is done by Stone & Webster, must be decided by the special conditions of each case, but it is probably true that most companies conducting a technical business find it desirable to subscribe to enough copies of each important journal in their lines to provide a file in each branch office as well as at headquarters.

Reinforced Concrete Floor Plates or Slabs.

The problem of determining stresses in either rectangular or circular plates supported or fixed along their edges has always been a complicated matter in the theory of elasticity of solid bodies, and there has never yet been established a satisfactory simple theory of such plates. Nor have there yet been made enough tests of the bearing capacity of such plates, either to enable purely empirical formulas to be established or to determine empirical coefficients for the analytic formulas of the provisional theories thus far proposed. The whole subject was considered to be more of analytic interest than of practical importance until the extended application of reinforced concrete to the construction of floor plates or slabs has given to it a degree of real importance which it hitherto has not possessed.

The Engineering Record has commented upon this general topic in the past, but the many inquiries which have lately been made regarding the proper methods to be employed for the design of these plates, and the regulations for their construction which have been proposed by many bodies, including the French government, show that the subject needs much more consideration.

In the issue of this journal of Aug. 3 there will be found a number of formulas set forth in the appendices of the reports of the British Joint Committee on Reinforced Concrete. There is no attempt in that report to go into any such extended and refined analysis as that given by Clebsch, Bach and others who have treated the problem as belonging wholly to the theory of elasticity. Perhaps it is as well that some approximate or conventional theory should be employed. That procedure certainly contributes to simplicity and avoids the complication of the exact theory, which, after all, is based upon such nice conditions regarding the supported edges and their continuity, when continuous, that they are never realized. It is in the interests of the actual features of the case, therefore, that approximate or provisional and simple theories should be adopted, in which empirical quantities may be introduced. What is needed is some reasonable expression for carrying capacity which may be made accurate enough for all practical purposes by an empirical factor determined by tests upon full-sized plates loaded as in actual use. The principal formulas of this class are those of Rankine and Grashof, or some similar formulas, with the later additions of Bach's empirical theory, and such regulations as those of the French government.

The formulas of Rankine and Grashof for rectangular plates are chiefly based upon their assumed division into narrow strips parallel to the two sides of the rectangle, these strips being supposed to be so loaded as to make their center deflections equal. Other formulas have also been based upon these fundamental assumptions, but developed into little different shape for the purpose of meeting the conditions otherwise ignored. These assumptions, like all of this conventional class, result in approximate formulas involving far too much error for unlimited use under any circumstances, but they yield forms which can frequently be effectively used in connection with tests of actual plates. In this manner factors or coefficients based upon such tests can be fitted to them so as to make them sufficiently accurate for purposes of design, within limits wide enough to give them much practical value.

The assumption that these strips of plate at right angles to each other must have equal center deflections is, of course, erroneous for all except those that are axial to the plate, and in the vicinity of the four sides of the plate the error is large. Again it is always assumed in this particular class of problems that the distribution of pressure along each edge of the plate is uniform, a condition never realized and sometimes very far from being realized. In the case of reinforced concrete plates, fortunately, this particular assumption probably does not involve material error. On the other hand, such plates are almost invariably continuous and the degree of fixedness around the edges is not only undeterminable, but it varies with the amount and position of loading. Under such circumstances, it is manifestly impossible to determine any accurate theory of treatment. The only possible procedure giving any promise of practical value is that already indicated, viz.: to test plates in as near actual conditions of use as possible, observing carefully their action with different loadings up to failure and then by aid of these tests to fit empirical quantities to the best form of approximate formula which can be devised.

The recent tests of Bach indicate that the greatest bending moments in square plates, and those nearly square, are found along the diagonals, and this probably holds for plates that are considerably oblong in shape, but not for long and narrow plates. In the central portion of the latter, at least, the line of maximum bending moment usually is parallel to the two longer sides.

The carrying capacity of plates, both rectangular and circular, needs a most careful and comprehensive analytical study, as well as an equally extended experimental investigation with their sides either continuous or simply supported. With the extensive use of reinforced concrete for floor construction, it has become of great practical importance to have available methods of design which can be depended upon to yield reasonably accurate results, especially for the heavy floor loads now required for both storage purposes and manufacturing machinery.

Notes and Comments.

Patching Reinforced Concrete is often done so quickly that the engineer in responsible charge of the work is unable to see just what conditions are hidden by the patches. It is well known, however, that sometimes these conditions are decidedly bad and indicate a lack of careful workmanship which should not be tolerated. Mr. H. M. Kennedy has recently made the suggestion that the building code of a city should prohibit such patching until the spots to be covered have been examined by a city inspector. Just how this rule would work in practice is somewhat doubtful, for the trouble in getting an inspector to pass on work is already serious in some cities and causes delays which reach a large total in a building operation of some magnitude. Mr. Kennedy states that in the work of his company a rule of this sort was put in force some years ago, according to which absolutely no patching is allowed to be done on concrete work immediately after it is stripped of its forms until it has been thoroughly examined and passed by the company's own inspectors. The result has been that every superintendent, foreman, and workman realizes that the work done under his supervision or by him is subjected to a minute scrutiny, and in consequence the character of the work has risen considerably above what it was before the rule was adopted.

The New Haven Electrification described last week is particularly interesting to railway civil engineers as departing from the third rail construction which has been in this country the accepted means of current supply when large units are used. Granted the use of high voltage, which is the condition of success in heavy railway work, the third rail becomes progressively less desirable as the voltage increases. At 11,000 volts, the pressure used for distribution on the New York, New Haven & Hartford, overhead construction is a necessity, and the engineers in charge very evidently made up their minds to take no chance in installing it. For high-speed work with an overhead trolley the catenary construction is also necessary. The section of road concerned contains a varying number of tracks and could not well be broken by pole lines, and the result was exceedingly solid, although costly, bridge construction. No electric traction system has ever been put in under more strenuous conditions than this, since the terminal requirements of direct-current operation demanded not only motors of very remarkable properties, but a complete duplicate collection and control system. It was wise policy to take no chances with the overhead equipment, making it mechanically as sound and perfect as possible regardless of cost.

Alternating Current Frequencies are now receiving the earnest attention of electrical engineers to whom they have the same significance that the battle of the gauges had to railway engineers a quarter of a century ago. At the present time 60 and 25 cycles are standard American frequencies, although others are in use in old plants. It is now seriously proposed to add another frequency to the list, 15 cycles per second, for the sake of the recently developed single-phase series-motor, for interurban and electrified steam railroads. The output of an alternating-current series motor is increased by lowering the frequency from 25 to 15 cycles per second, although the amount of increase is a matter of difference of opinion, those in favor of the change claiming 30 per cent. to 35 per cent., and those opposed claiming only about 15 per cent. The reduction in frequency would involve an increase in the size and weight of the generators at the power houses and of the transformers, both step-up and step-down. The question at hand is whether a certain percentage more motor power can be placed on a single-phase locomotive sufficient to pay for the inconvenience and expense of a change in frequency. The question is a serious one from the standpoint of the future, although not a serious one from the standpoint of the present. Railroads, more than any other engineering structures, must correspond, and be built to standards. If one large railroad should become electrified at a frequency of 15 cycles per second, it would probably necessitate the sequence of future roads on the same frequency. It would then probably be too late to retrace steps, or change the frequency.

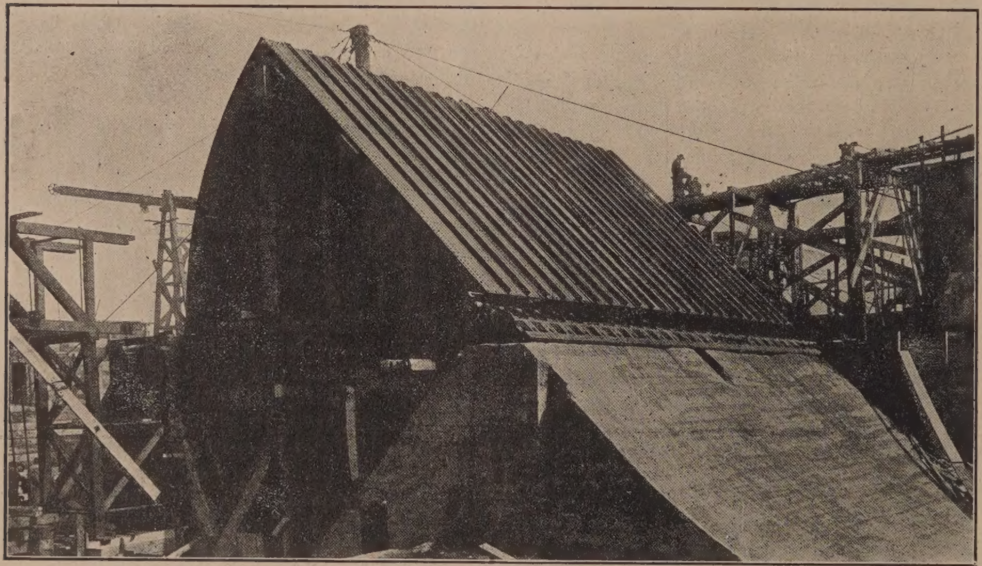
Molecules and Electrons were the cause of a battle royal at the recent meeting of the British Association. So far as the molecule is concerned it would be difficult to mention any proximate doctrine that has been more important to theory and practice than the splendid speculation of Kekulé, and yet in view of the work of Van t'Hoff and his successors no chemist would seriously defend the thesis that the carbon atoms in a molecule of benzol are literally arranged in the conventional hexagon. It is quite sufficient that they behave in many respects as if they were actually hooked together with valences. As with the molecule so with the atom. For more than a quarter-century past it has been perfectly well understood that the atom must be dynamically complex and the epoch-making work of Mendeleéf left little doubt in the mind of any serious thinker that the so-called elements are in some way structurally related. As to the electronic theory of matter, it works out very prettily up to a certain point, like other theories of matter and then gets into trouble. If one postulates subatomic particles endowed with any plausible set of properties, their interactions can be made to fit a large number of the more general properties of ponderable matter, as witness various speculations from the day of Æpinus up to date. We have had Maxwell's idlewheels and the vortex atom and a few others within recent years, and it does not help the matter much to call the fundamental unit chosen "electricity." Truth to tell, there is very little known experimentally about the electron and until more is found out about its dimensions and relations, its derived properties are of secondary interest. This much is clear, that a sufficient breach has been made in subatomic dynamics to justify an assault in force, which, whether it succeeds now or a century hence, can never wholly be driven back. Great experimenters are particularly needed just now and they are painfully scarce. There is a tendency toward rushing into print with work half completed and ill done that is perhaps in keeping with the spirit of the times, but which accords poorly with scientific conscientiousness.

The Power Development which the Chicago Sanitary District Trustees desire to carry out by extending the drainage canal through Joliet and erecting a plant at Brandon's Road seems likely to arouse a bitter struggle in the legislature before the bill authorizing the work is passed. According to a statement issued by a Joliet taxpayer, Mr. John H. Garnsey, the electrical power now generated at Joliet is developed at a dam owned by the State but leased to the Economy Light & Power Co., and if this dam is removed as proposed by the Sanitary Trustees and a new one built 2 miles below it, neither the city nor the State will be able to exercise any control over the power. The 35,000 to 40,000 h.p. which the Sanitary District Trustees expect to generate at the lower dam, will be used for the benefit of the Sanitary District and the people of Joliet will suffer thereby. In reply to this statement, President R. R. McCormick, of the Trustees, has given out a letter stating that the company purchased for less than $100,000 the marsh land at the proposed terminus of the canal extension and has fixed a price on it of $3,000,000 to the Sanitary District. It is the latter which will make the property valuable by constructing the canal extension and the Trustees do not believe they should be held up for the benefits their work creates. No promise to furnish 40,000 h.p. has ever been made, but on the contrary the Trustees have offered to furnish the city of Joliet with current at a price equivalent to $38 per street light per year, an offer which was not accepted, although the Economy Co. is paid $75 a year. It is evident from these extremely divergent statements that there is a good prospect of hearing some important debates on hydraulic power development at the next session of the Illinois legislature.

MOVABLE CREST DAMS AT THE WATER POWER DEVELOPMENT OF THE CHICAGO DRAINAGE CANAL.

Two movable crest dams, one 12 ft., and the other 48 ft. in length, are included in the water-power development of the Chicago Drainage Canal at Lockport, Ill. This power development will render available 33,000 h.-p. at the turbine shafts, based on a uniform flow of 600,000 cu. ft. per minute under the head of 36.5 ft. obtainable at the development, and on the guaranteed hydraulic efficiency of the turbines of 80 per cent. Under actual working conditions with an average flow at the rate of 600,000 cu. ft. per minute for the entire 24 hr. there will be available for peak loads 50,000 h.-p. or more, depending on the load factor. The works required to develop this power include an extension of the canal 10,700 ft. long, with a uniform channel width of 160 ft. and a nominal depth in this channel of 24 ft., the extension being partially in excavation and partially between concrete retaining walls and earth and rock embankments, a 69x380-ft. two-story power house and a tail race in earth and rock excavation, which is 6,800 ft. long, 160 ft. wide and affords a minimum depth of 22 ft. of water.

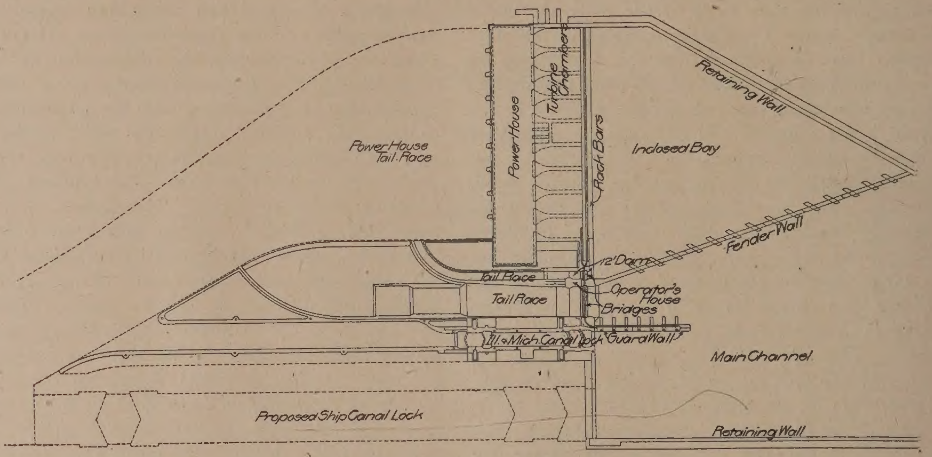
The canal extension is widened at its end at the power house to 522 ft., by a change in the direction of the right-hand retaining wall containing it. A forebay is thus provided for the power house, and space is obtained in a cross wall at the end of the head race and between the left-hand retaining wall of the latter and the off-shore corner of the power house for the two movable crest dams, a lock for the Illinois & Michigan canal and a lock for the canal of the proposed Chicago to the Mississippi River deep waterway. The power house has nine water turbine chambers on the upstream side which open directly into the forebay of the power house and are protected by trash racks, inclined slightly from the vertical. A heavy concrete fender wall, 525 ft. long, is built across the forebay from the right-hand retaining wall of the head race to the stream end of the power house, making an angle of about 80 deg. with the upstream side of the latter. This wall has fourteen arched openings in it, the tops of the openings being submerged at normal stages of water in the head race, and is provided to prevent vessels and large obstacles reaching the forebay. The 12-ft. movable crest dam is 45 ft. from the offshore upstream corner of the power house, in the cross wall at the end of the head race and inside of the downstream end of the fender wall. The 48-ft. movable crest dam is separated from the 12-ft. one by a concrete and iron structure, 12 ft. wide, which contains the operating apparatus for both dams; this dam is immediately in front of the downstream end of the fender wall. Beyond the larger dam and separated from it by a 24-ft. length of the cross wall at the end of the head race is a 20x220-ft. lock for the Illinois & Michigan canal. A heavy concrete guard wall, 150 ft. long, is extended upstream between the larger dam and the lock, at right angles to the cross wall of the head race, to prevent vessels being carried against the dam. Between the lock and the left-hand retaining wall of the head race is a 150-ft. length of the end wall of that race in which the end of a lock for the proposed ship canal can be built.



Sector of 48-foot Dam, Blocked up during Construction.

The two movable crest dams are provided to furnish a passage for all drift, such as ice, floating materials, waterlogged and submerged driftwood, and so forth, which cannot safely pass through the water turbines in the power house; and for controlling the rate of flow in the main drainage channel at times when only a portion of that flow is passing through the power house, and when otherwise necessary. Controlling works at one side of the end of the portion of the canal which is now in service are used at present for regulating the rate of flow in the Drainage Canal. These works are just above the upper end of the head race of the power development, the flow through them being discharged into the Des Plaines River. When the power development has been placed in service these works will be used only in an emergency. The two movable dams at the power house will then regulate the rate of flow, a vertical butterfly dam across the upper end of the head race being provided so the flow into the race may be shut off, if desired.

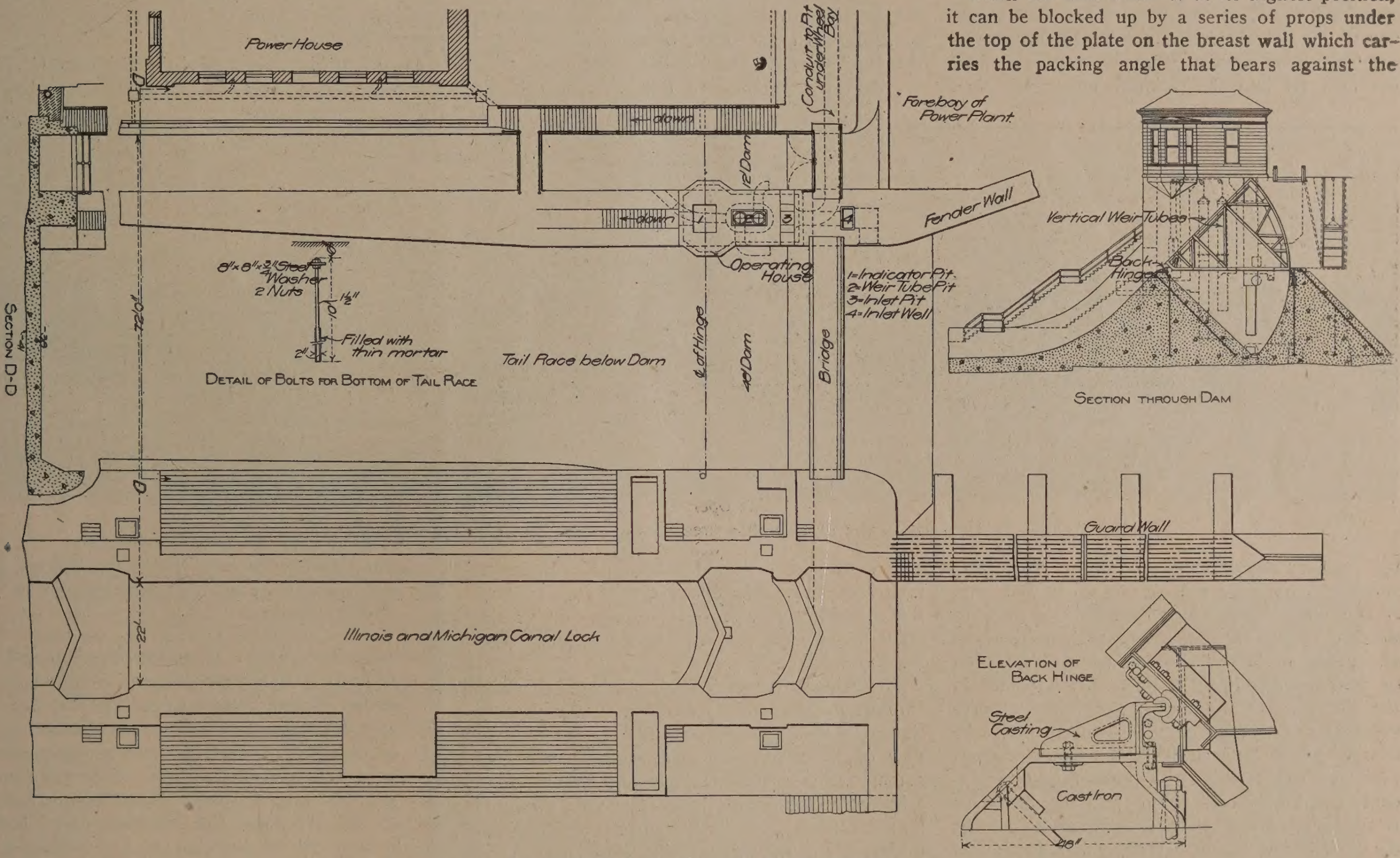
The 12-ft. dam is designed to provide means of passing all drift that finds its way under the fender wall into the enclosed bay above the power house. The trash racks over the openings into the turbine chambers of the power house are extended above a platform over those chambers. The upper end of the rack curves over a narrow-gauge track, which is laid on this platform and extends the length of the rack, so that small cars on the track will come partially under the curved ends of the latter. The trash which will collect on the rack may be pulled up over the end of the latter into the cars, which can then be run out on a bridge over the 12-ft. dam and dumped. The narrow-gauge track also extends across a bridge over the 48-ft. dam and out to the end of the guard wall of the canal lock. Machinery parts for the power house equipment may thus be delivered on vessels in the canal and then taken to the power house on this track.



General Plan of Works at the Power Development Site.

The two movable crest dams are practically alike in details of construction and operation. Each movable crest is built of structural steel shapes and steel plates and is practically a 45-deg. sector of a cylinder with a 26-ft. radius. Each sector is hinged horizontally along the axis of the cylinder of which it would form a part, to the top of a back wall on which it is mounted on the downstream side. The radial deck plane and the curved upstream front of the sector are made watertight with steel plates, the deck being provided with steel angles for ice skids. The deck plane, the lower radial plane and the curved face are heavily reinforced by intermediate steel frames. When the crest formed by the intersection of the curved face and the radial deck plane is at the maximum operating height, the lower radial plane of the sector is horizontal. As the crest is lowered the sector rotates on its axis and moves into a space in the concrete base which is also approximately a sector of a cylinder, of about the same radius as that of the crest, the radial deck being horizontal when the crest is at its lowest position. The crests of both dams have a vertical range of 18 ft. from 2 ft. above to 16 ft. below Chicago datum, the water surface above the dams being 4 to 6 ft. below that level under normal conditions of flow.

The clearances and packing details between the ends of the movable sector and the faces of the concrete wall in which the sector is inserted, between the curved face of the sector and the top of the breast wall of the base and at the hinge on which the sector rotates are designed to confine the water in the chamber under the dam. Water is admitted to and discharged from this chamber through controlling valves provided for the purpose. Air pipes under the radial deck of the dam are designed with details to maintain a free water surface in the chamber. The operation of the sector dam is similar to that of a beartrap dam, the pressure due to the head of water under the sector balancing the weight of the latter and that of the stream flowing over it. This equality of moments holds for all positions of the crest, so that the sector being in equilibrium may be raised or lowered simply by raising or lowering the level of the water in the chamber under the dam. The height of this water level is controlled by a special balanced valve, called a weir tube, which is placed in a pit under an operating house between the two dams and is easily moved by a hand wheel in that house. Under the conditions of operation, the head of water required in the chamber will always be lower than the available head in the head race, the level in the latter ranging from 8 ft. below to 2 ft. or more above Chicago datum, in extreme cases.



Arrangement of Movable Crest Dams.

A heavy cast-iron bed plate anchored to the top of the back wall of the concrete base carries the hinge on which the movable crest rotates. The anchorage for this bed plate consists of two rows of 2½-in. bolts. One row of these bolts is along the inner edge of the bed plate, the bolts being 2 ft. apart and extending vertically 16 ft. into the concrete base to anchor plates; the tops of the bolts in the other row are attached along the outer edge of the cast-iron bed plate, these bolts, which are 2 in. in diameter and 1 ft. apart, extending back at a 45-deg. angle to anchor plates 24 ft. from the face of the dam.

A cast-steel hinge chair is bolted to the heavy cast-iron bed plate on the back wall. This hinge chair is in 5-ft. 11 15/16-in. lengths, a clearance of 1/16 being provided between the lengths, a ¼-in. groove filled with cork packing preventing leakage. A 4-in. annealed steel journal is carried by the hinge chair and operate in a babbitted hinge box which is bolted to the movable sector. The hinge forms a water-tight joint between the concrete base and the movable sector. The upper and lower radial planes of the latter do not come quite to an intersection, but are connected by a tight diaphragm of steel plates to which the hinge box of the joint is attached. Two 1½-in. extra-strong galvanized-iron pipes are placed the length of the joint and have connections by which they may be supplied with live steam, so the joint may be kept free of ice in severe weather in case no water should be flowing over the dam.

The face of the concrete walls at both ends of each dam are sheathed with steel plates riveted to Z-bars built into the concrete. These plates are normal to the hinge axis of the movable crest, and are ¼-in. from and parallel to the finished end of the latter at 60 deg. Fahr., so that the sector may rotate through its arc of 45 deg. and have ¼-in. clearance in all positions. In order to make these joints between the sector and the walls practically water-tight, a 1½-in. angle is placed loose over each joint the length of the deck plane of the sector. The tendency of the water flowing over the dam to enter the dam chamber through the joints at the end of the sector holds these angles in the joints. The angles are attached in such a manner as to prevent them from floating away or from being torn off by debris flowing over the crest. They are held against the side of the concrete wall by stiff steel springs. As under certain conditions the water in the dam chamber will tend to flow out of the latter, the joints at each end are also packed with brass on the inside along the part of their lengths where such outward flow might occur.

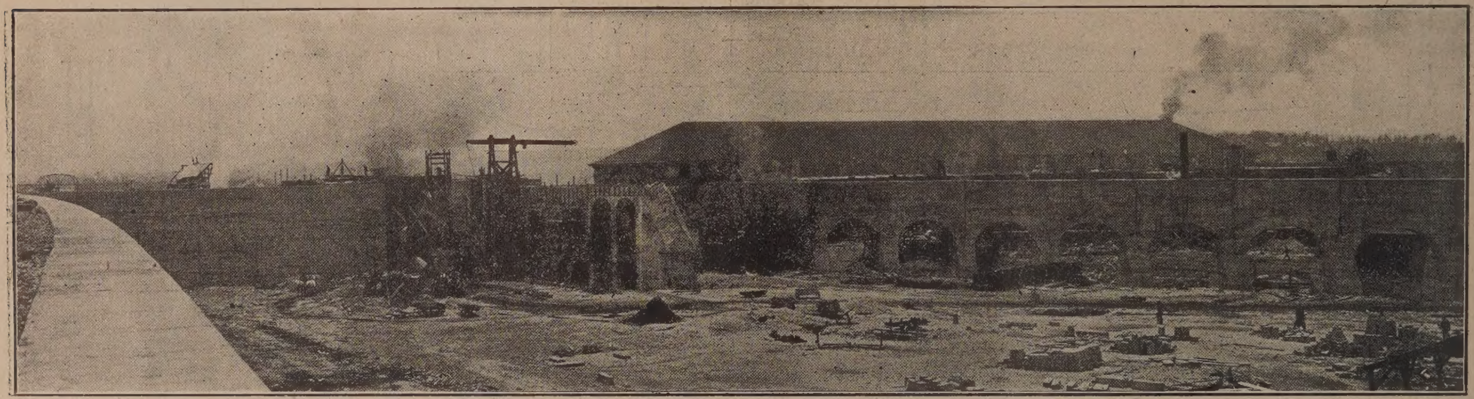
The joint between the curved face of the movable sector and the curved portion of the breast wall of the concrete base forming one side of the chamber under the sector is packed at the top of the breast wall in a manner which is designed to render it watertight. The plates which form the curved cylindrical face of the sector have planed edges and have the rivets which attach them to the frame of the sector countersunk. A steel angle, in 6-ft. lengths, is attached horizontally to a steel bed plate on top of the breast wall in such position that the full face of one of its legs bears against the curved face of the sector.

Three 1½-in. extra strong pipes to each panel of the sector connect the upper part of the chamber under the dam with the atmosphere and provide free air circulation above the water in the chamber. One of each three of these pipes permits a free flow of air or water into or out of the chamber, but the other two are provided with check valves which prevent an outward flow so the water will not be siphoned out of the chamber. Such water as may leak into the chamber will be carried away by the pipes, however, if the water level rises above the level of the openings of the latter.

When the dam sector is at its highest position, it can be blocked up by a series of props under the top of the plate on the breast wall which carries the packing angle that bears against the curved face of the sector. These props are notched cast-steel pawls which are spaced 12 ft. apart and are keyed to a 2 11/16-in. steel shaft so they can all be moved together. When the sector is resting on these props the water may be discharged from the chamber under the sector and the chamber entered for inspection, cleaning, and so forth.

The operation of both dams is controlled from a one-story concrete-block house, 12x26.5 ft. in plan, between the two dams. This house covers three pits in the concrete substructure on which it is built. These three pits are in a row, the axis of which is normal to the axis of the dams. The upstream one is called an inlet pit and is divided by two transverse walls into three wells; the middle well of this pit is connected through a conduit in the concrete wall between the two dams with the canal just above the 48-ft. dam. The port of this conduit is covered by a coarse trash rack mounted on a frame set flush with the vertical face of the wall. The water passes through a fine mesh rack in a wall between the end of the conduit and inlet pit before reaching the latter. The middle well of the inlet pit contains three valves; a pipe in the bottom of this well connects the two outside wells and is fitted with a gate valve, and the wall separating each outside well from the middle well is built with an opening, controlled by a sluice gate valve, through which the flow of canal water into each of the outside wells is controlled. All three of these valves are fitted with non-rising stems which terminate at the level of the floor over the pit and are operated by removable wheel keys. The inlet well, and through it the chambers under the dam, may be emptied through a conduit leading to the pit under the wheel bay in the power house.

Each of the two outside wells of the inlet pit communicates both at the top and bottom with the chamber under its corresponding movable dam. As the arrangement of the two wells is the same, a description of one will serve for both. The outer wall of the well is formed by the sheathing plates on the face of the wall at the end of the movable sector. Beneath the sheathing plate is an opening from the outside well of the inlet pit into the chamber under the dam, this opening being controlled by a sluice-gate valve with its valve rod passing up in that well. A rod on a lever which controls the shaft to which the props for supporting the dam are keyed also passes up in this well. A removable section or door opening into the inlet well is placed in the sheathing at the top of the well and provides means of entering the chamber under the dam when the latter is blocked up on the props in its highest position. In order to avoid accident to the operators or to the dam, this door is so designed that when it is in place it locks the rack bar which operates the dam props and the valve rod which operates the sluice gate at the bottom of the chamber.


Fender and Guard Walls at Movable Crest Dams from the Upstream Side.

A pit containing two vertical weir tubes is next to the inlet pit under the operating house. These weir tubes are made of 26-in. pipe and are swung from the top on chains passing over a pair of pulleys to counterweights. One of the tubes is connected with the chamber under one dam and the other with the chamber under the other dam, the water flowing out of these chambers over the circular weirs formed by the tops of the tubes. The height of the water level in these chambers can be regulated therefore by varying the height of these circular weirs, and the position of the crest of movable sector will thus be changed accordingly. This regulation of the height of water in the two chambers can be done separately or together, and is under perfect control at all times. An outlet conduit leads from the weir tube pit to the tail race of one of the dams.

The third pit under the operating house is at the downstream end of the substructure under the latter and next to the weight tube pit. This third pit has a window or door at the bottom on the tail race side and communicates with the chambers under both dams and with the outlet conduit from the weir tube pit. It contains a steel shaft and crank from each dam, harnessed in the operating room above to models of the dams which will indicate separately all the positions of each dam. Two pairs of 12-in. float gauge pipes, 12 ft. long, are also located in this pit and have connections which will indicate through floats attached to pointers, all stages of water above the dams and in the chambers under the latter. The pit is covered with a steel angle frame carrying a floor of hinged cast-iron plates. The weir tube counterweights and gears for operating the two weir tubes by means of floor stands in the operating room are placed under this floor. A bay window is placed at both ends of the floor over the indicator pit, in the sides of the operating house. The indicating gauges for one dam, the wheel for operating the gear of one weir tube, the model showing the position of the one dam, and so forth, will all be placed close to one of these windows and the similar apparatus for the other dam close to the other window so that they will be in easy sight and reach of the operator as he stands in the window. The operator may thus observe the movement of the crest of the dam as the regulating devices are manipulated, without leaving those devices.

The bridge over each dam opening in the end wall of the race is placed so a needle dam of timbers may be placed across the opening and the flow of water over the dam cut off as a final resource in case of an accident to the dams, or to a butterfly dam across the head race at the junction of the latter with the main canal. These bridges are of the through plate-girder type, their bottoms also being plate girders in order to bring both side girders into play when the upper ends of the timbers of the needle dam are placed against the girder on the upstream side. The lower end of the needle dam timbers will rest against a cast-iron plate in a shoulder on the upstream side of the base of the dam.

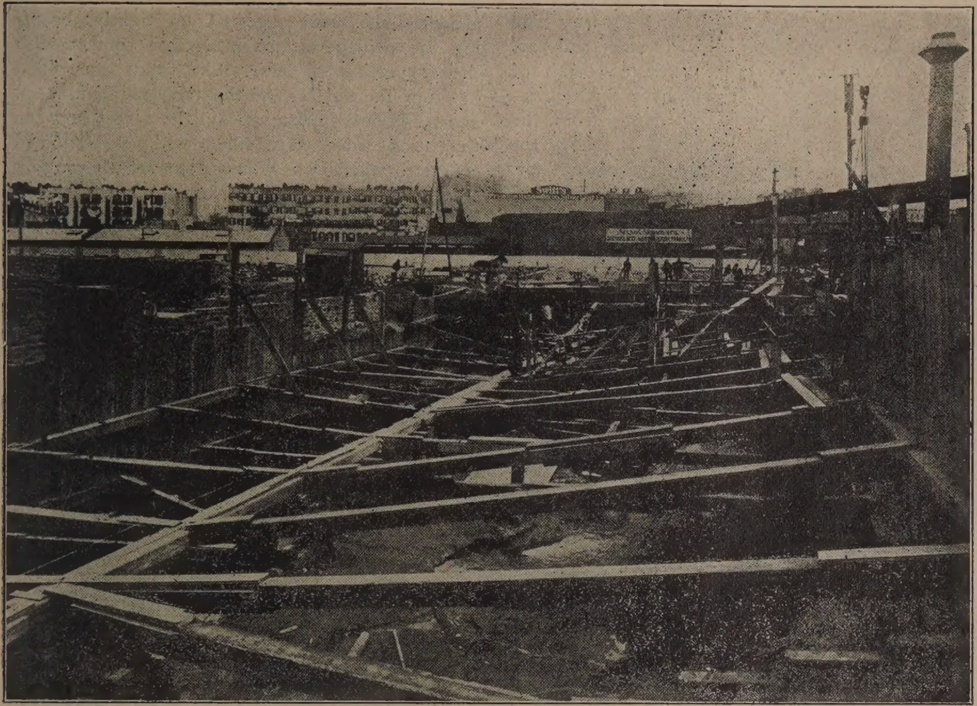
The downstream faces of the back wall of both dams is designed to suit the various conditions of flow. The 12-ft. dam has a tail race, 12 ft. in width, which connects with the tail race of the power house. The 48-ft. dam also has a tail race, 575 ft. long, connecting it with the tail race of the power house. Under certain operating conditions 40,000 h.-p. in water will pass over the 48-ft. dam, and will have to be dissipated between the latter and the tail race of the power house. Experience with the bear trap dam at the controlling works on the main canal has demonstrated that careful preparations must be made to gradually reduce the velocity of the water flowing over such a dam. The tail race of the 48-ft. dam is designed specially to break the force of the water flowing over the dam, without violent disturbance at any point. In the first 110 ft. of the race the width is gradually increased to 54 ft., the bottom dropping away from the dam on a slight grade. The bottom in this length is lined with a concrete floor anchored by bolts to the solid rock on which all of the structures of the power development are built. At the end of this 110-ft. length the bottom drops 11 ft. in 10 ft. forming a 55x75-ft. pool; beyond this is a second pool, 55x60 ft. in plan, which has 3 ft. less water in it than the first. A channel still 3 ft. more shallow than the second pool extends from the latter to a weir over which the water is discharged into the power house tail race. This weir has a total length of 275 ft., the tail race widening out to form a pool of that width just above it. A length of 48 ft. of the weir at one end has its crest 2 ft. above the bottom of the large pool at the lower end of the race; the crest of the balance of the weir is 5 ft. above the bottom of that pool. One side of the tail race is built on a curve so the principal flow over the dam will follow along it and pass over the low portion of the weir.

The power development of the Drainage Canal is being carried on under the direction of Mr. Isham Randolph. Mr. E. L. Cooley designed and detailed both of the movable dams.

SEWAGE DISPOSAL AT NORWICH, ENGLAND, will be conducted in an unusual manner, according to the London "Times," which states that Mr. A. E. Collins is the engineer of the works. The sewage will be forced by centrifugal pumps against a head of 117 ft. through a 33-in. reinforced concrete conduit about 2½ miles long to one or both of two vertical pipes and discharge over bell mouths into one or more of four detritus pits. The latter will have sharply sloping bottoms, and will be provided with sludge outlet valves leading to Shone pneumatic ejectors, by means of which the detritus can be delivered through rising mains to the higher levels of the farm. The arrangement of these pits is such as to enable nearly the whole of their cleansing to be done without stopping the flow of sewage through them. After leaving the detritus chambers the sewage flows over measuring weirs into the common supply channel of four hydrolytic tanks. The sewage leaves these tanks under a "skimming wall," and passes into further hydrolytic chambers provided with what are known as hydrolyzing cells. These cells are constructed with a large number of nearly vertical slate divisions, the object being to present as extensive a surface as possible. The solids in solution deposit upon these surfaces in the form of a feathery sludge which, on reaching a certain thickness, mostly falls to the bottom. It is removed from the tanks at intervals without interfering with their working; and flows to the Shone ejectors. The effluent will be used for irrigation of farming lands.

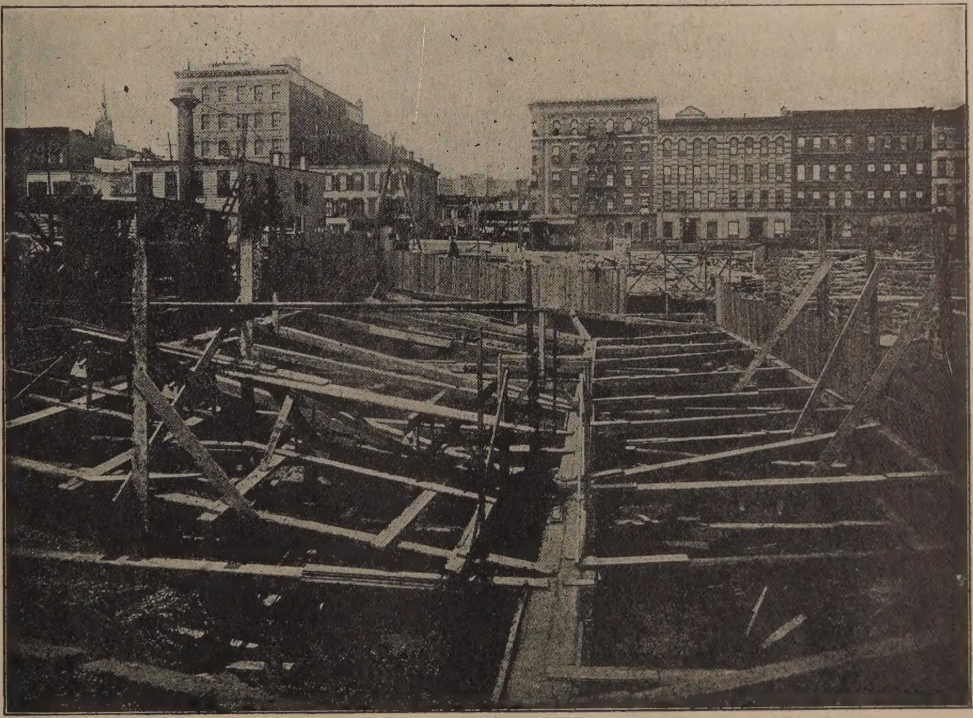
Retaining the Sides of a Large Excavation.

The new six-story steel-frame wholesale meat market building for Swift & Co., at 153rd St. and Brook Ave., New York, with its vaults under the 20-ft. sidewalk on two sides, occupies a 65x135-ft. area which has been excavated to a depth of about 21 ft. through 10 ft. of loose fill above a deep stratum of fine sand and quicksand, with abundance of ground water at a distance of about 12 ft. below the surface. The site was originally the bed of a considerable stream, which has not yet wholly disappeared, making it necessary to deal not only with ordinary ground water, but with a considerable subterranean flow. This condition, together with the treacherous and irregular character of the soil, made the excavation difficult and necessitated careful provision for the exclusion of as much water as possible from the pit and for the safe support of the earth on the outside. The sheeting was therefore designed not only to resist a heavy earth pressure, but to act also as a core wall or dam to intercept the flow of underground water. The soil was so wet and soft that the bottom of the pit offered very little resistance to vertical or horizontal pressure and would not afford a reaction for ordinary spur braces, so that a special system was designed to resist the external pressure on the sheeting.



Sheeting and Bracing the Excavation for the Swift & Co. Building.

A row of pits about 6 ft. square was sheeted down to a depth of 20 ft. at equidistant points on a line parallel with a long side of the excavation and about 20 ft. from it. A double line about 70 ft. long of 12x12-in. horizontal timbers, laid close side by side and breaking joints, was supported on the cribs at one end of the lot just above the bottom of the main excavation, which at this time had been carried, by preliminary open work, to a depth of about 12 ft. below the original surface. A narrow trench about 4 ft. deep was dug just beyond the line of excavation on each of the long sides of the lot, from end to end, and in each of them was laid a continuous line of 12x12-in. rangers. Transverse 10x12-in. timbers about 20 ft. long and 12 ft. apart were laid in inclined position on one side of the intermediate horizontal girder and their ends were abutted ad wedged against its vertical face and that of the outside ranger timber. Similar 12x12-in. inclined struts 45 ft. long were laid in the same planes on the opposite side of the intermediate girder and wedged against the corresponding ranger. The long struts were made in two pieces, spliced with butt joints and with a scab, and all of them were connected at both ends to the horizontal timbers by top and bottom scab pieces. Shallow trenches were dug to receive them where necessary and care was taken to locate them so as to clear the steel columns and piers in the frame-work of the building.



View Showing Excavation Carried to Greater Depth.

On one side of the lot where the excavation reached a maximum of 21½ ft. depth, 3x10-in. tongue and groove sheeting 24 ft. long was started on the outside of the ranger, and on the opposite side, where the excavation had a maximum depth of 14 ft., 2x10-in. tongue and groove piles 14 ft. long were started simultaneously with them. As the piles were driven, excavation was carried on, care being taken to keep the bottom of the pit generally 2 or 3 ft. above the lower ends of the piles, thus reducing the tendency of the quicksand in the bottom to rise. After the excavation was deep enough to develop considerable external pressure on the sheeting and bring the inclined braces to a solid bearing against the intermediate girders, one end of the latter was braced against the transverse ranger laid across the lot on the line of excavation and the opposite end near the center of the lot was temporarily secured by rakers, with their lower ends bearing against distributing timbers like grillages or dead men buried in the soil. Sheet piles were driven across the outside face of the end ranger and the excavation carried on inside of them; the external pressure they received was largely transmitted to the intermediate horizontal girder, where part of it was absorbd by the end raker and the remainder was absorbed by friction with the struts or was directly transferred to the side sheeting by a pair of special struts in the planes of the regular transverse struts, which were inclined about 80 deg. from the direction of the main girder so that their vertex pointed toward the line of transverse sheeting. The ends of these struts were scabbed to the center and side rangers like the regular transverse struts, and as any displacement in the center ranger tended to force them into a transverse line, they acted like a toggle, setting themselves tighter and tighter as the pressure increased and transferring it to the side rangers. By this device the pressure against the end sheeting was successfully resisted until the lines of rangers, the transverse bracing, and the side sheeting had been placed the full length of the lot and the intermediate ranger was made to abut against the transverse ranger at the opposite end, thus transmitting the pressures from one end to the other and dispensing with the need of the inclined rakers.

As the excavation progressed a second system of rangers was set against the sheeting about 6 ft. below the first and was braced through the intermediate ranger in the same way. Undue deflection in the transverse struts and in the intermediate ranger was prevented by the use of cribbing and vertical shores wherever necessary, which were changed to correspond with the increasing depth.

The sheet piles were driven by a No. 4 Ingersoll-Sergeant steam drill with the rotating device removed and the drill replaced by a square steel bar. A flat steel bar was bent to form a rectangular frame and bolted to the drill enclosing the lower end. A rectangular hole through the flat end of this frame engaged a corresponding projection formed by a steel anvil block riveted to the upper side of a driving cap. The cap was simply a piece of a thick steel bar bent to a U-shape and fitted snugly on the top of the sheet pile. A pair of handles were bolted to opposite sides of the drill so that it was easily kept engaged with the driving cap while striking it rapid blows that forced the pile down about 1 in. per minute when the point was 4 or 5 ft. below the surface. An expenditure of $15 transformed the machine from a rock drill to a hammer which did very satisfactory service on this work and has been adopted by the contractors for similar work in other places. It is thought, however, that the efficiency of the hammer would be promoted by increasing its weight 50 or 100 lb., as may perhaps be dône by adding castings to the framework. As it required 4 men to carry the hammer comfortably, it proved too heavy to hold, unaided, while in operation and was therefore suspended by a rope from overhead supports.

At first a pair of shear legs about 15 ft. high were set up on the edge of the excavation and served as towers for an old ⅝-in. derrick guy which was utilized for a sort of improvised cableway. The cable was rove through a snatch block, which, being reversed, served as a trolley for carrying the hammer over the sheet piles. While driving the sheet piles on the sides of the excavation, vertical posts were in some cases substituted for the shear legs to carry the cable-way, and in other cases the cable-way was replaced by a horizontal 2x12-in. plank 16 ft. long set edgeways at a clear height of about 12 ft. above the tops of the piles. This plank was supported at each end by a vertical post, seated on the top of the pile and having side pieces nailed to it to form jaws engaging the tops of the piles, so they could easily be slipped along from pile to pile. They were knee-braced by inclined struts spiked to the verticals and to the transverse horizontal struts.

The steam hammer was not in this case provided with a rolling support, but was merely suspended from a sling passed around the horizontal beam. In all cases the hammer was raised and lowered by a four-part hand tackle and required a vertical clearance of about 9 ft. for effective operation. The hammer was operated by two men on top guiding it with the handles and a third man below to adjust the pile cap.

The sheeting and bracing was accomplished in 5 weeks by an average force of 18 men. All of the excavation was done with pick and shovel, and the spoil was removed in wagons driven out of the pit on an incline at one end. After the sheeting was driven the water in the excavation was kept down by two Pulsometers.

The H. Wales Lines Co., of Meriden, Conn., is the general contractor, and the work above described was executed by Messrs. Miller, Daybill & Co., under the personal direction of Mr. F. Daybill, and Mr. H. L. Muchmore, superintendent.

The Colorado River Control work undertaken by the Southern Pacific Co. to divert the flow of the river from the Salton Sink was completed last month, and official announcement has been made that affairs are again in the hands of the California Development Co., which will have control pending an agreement between the governments of the United States and Mexico and the corporations involved. The Southern Pacific Co. has, it is stated, expended $1,500,000 in the work of closing the breaks in the bank which caused all the damage.

The Construction of the New York Central Office Building, New York.

An important feature of the terminal improvement for the New York Central & Hudson R. R. R. Co., now under construction in New York is the great office building occupying two complete blocks on Lexington Ave., between 43rd and 45th Streets. This building when completed will be about 275 ft. wide, 452 ft. long and about 280 ft. or 20 stories high above the curb, with one complete story and part of another extending to a maximum depth of 35 ft. below the curb. It will have three interior 62x130 ft. light wells extending from the roof to the second main floor 36 ft. above the curb which coincides with the first office floor. Below the street level the building will be used for train service, and the first story, which is very high and sub-divided for part of its area by a mezzanine floor, will be used for a branch post-office. The upper part of the building will be devoted entirely to office purposes.

The building is of steel cage fire-proof construction with cut stone exterior walls, backed with brickwork and with cinder concrete floors, roof and ceilings, and fire-proofing around all steel members. In a general way the building is symmetrical in plan around the longitudinal and transverse center lines. It will contain in all about 35,000 tons of structural steel and the estimated cost is approximately $9,000,000, exclusive of the value of the site. At present only the north end of the building, up to the sixth office floor, is under contract and this portion of it, which contains about 7,500 tons of structural steel, will be completed and the offices of the company transferred to it before construction is commenced on the corresponding lower part of the south end of the building, which is somewhat larger than the north end and will extend across 43rd street, containing two of the three light courts. The permanent floor of the sixth story will be built with the first section to serve as a temporary roof for the fifth office story and the thirteen upper office stories will be added at a future time not yet determined. The steel frame-work of the part now being erected is proportioned for the stresses produced by the full-height building and all of the structural details are designed for the requirements of the 20-story structure. A general description of the building and details of the structural steel work of fthe lower portion were published in The Engineering Record of Feb. 24, March 17 and April 7, 1906, and reference to them will show clearly many of the interesting features of the steel work alluded to in this article.

The general contract for the lower part of the building was awarded to the John Peirce Co., and in January, 1906, work was commenced on the first part of the building, 220 ft. long at the north end, reaching from 44th to 45th street. The ground had already been cleared and the excavation made to the required depth of about 20 ft. below the curb by the contractor for the yard improvements, who had also built at this point a massive concrete retaining wall adjacent to Lexington avenue. The general excavation for the building was carried everywhere into the solid rock, for the column foundations. In the entire building there are about 180 main columns and a large number of short subcolumns, many of which carry extremely heavy loads and are seated on single-tier I-beam grillages proportioned for a maximum pressure of 36 tons per square foot on the surface of the rock. In a few instances where cast-iron pedestals and short concrete piers were adopted the latter were reinforced and loaded with the same unit pressure which gives a very liberal margin over the maximum of 50 tons per square foot allowed by the Building Department.

All grillages are made with three to nine 24-in. 100-lb. I-beams, connected with three lines of tie-bolts and gas pipe separators. After the beams for each grillage were assembled together they were suspended by vertical bolts from pairs of transverse girders supported on blocking and very carefully adjusted with their panel lower flanges at the exact height required for the top flanges of the grillage beam. The suspender bolts were screwed up tightly, bringing the grillage beams into close contact with the supporting girders, while grout was filled in from the surface of the rock to about 1-in. above the bottom flanges, and the spaces between the beam webs were filled with well-rammed concrete, which was allowed to set thoroughly before the supporting girders and suspension rods were removed.

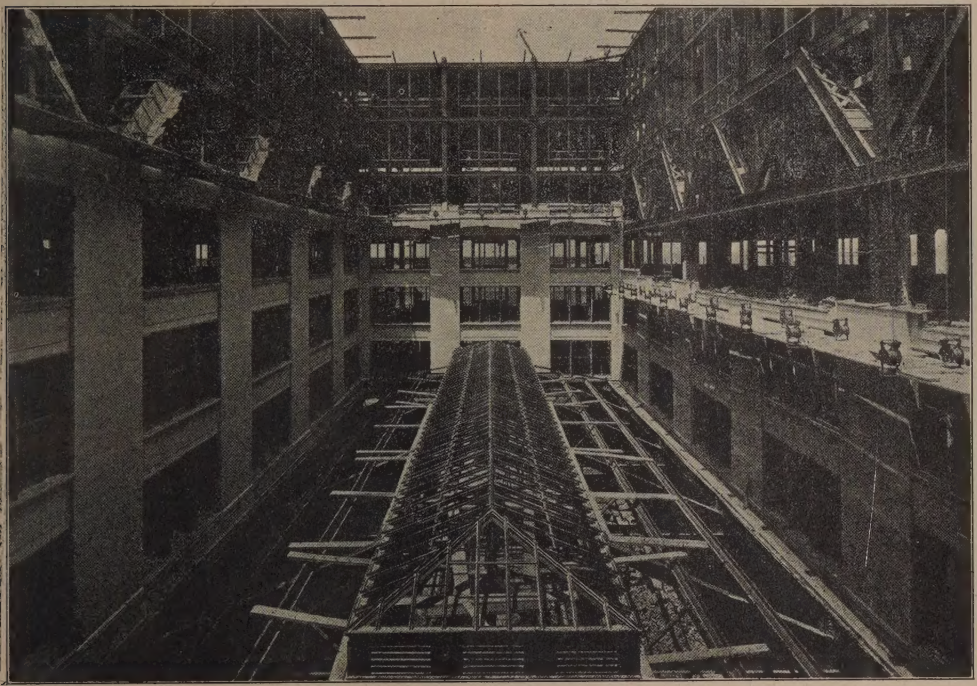
Timber cribbing was built up from the bottom of the excavation to about 18 ft. above curb level and on it were erected two wooden travelers each consisting of a horizontal platform with two stiff-leg derricks braced together at the forward corners. The derricks had wooden masts about 35 ft. high and steel booms about 60 ft. long, with a capacity of 15 tons each. The 20x30-ft. platforms were mounted on double-flange wheels running on rails spiked to 12x12-in. longitudinal stringers. These travelers unloaded the columns and girders from trucks in the street and assembled them in the structure. After erecting the first panels of columns and girders, the traveler truck was transferred to the floor-beams and thereafter the travelers moved on the completed portion of the frame-work and the use of cribbing was dispensed with.

Great energy was displayed in erecting the first two tiers of steel work as rapidly as possible so that the street floor could be built and the story below it used for the suburban passenger traffic which was put in service there in December, 1906. As it was necessary to complete entirely each tier of beams as fast as the traveler was advanced, there was considerable danger of interruption to the work through possible delay in receiving some of the beams or girders and therefore above the postoffice floor the travelers were largely superseded by four guyed derricks with 60-ft. booms arranged so as to command the entire area of the building and the adjacent street, making it possible to unload and erect materials without rehandling. These derricks were lifted up every second tier and were operated by Lidgerwood hoisting engines with separate boilers, two of which were located on the street floor and two on the third floor to avoid obstructing the trains in the basement story.

The special design of the building involved extremely heavy column loads and long span girders and resulted in the production of very massive members to be handled by the travelers and derricks. Among these were the bottom sections, over 50 ft. long, of columns with loads of over 3,190,000 lb., each which were made with special sections tapering from 24x24-in. at the top to 24x58-in. at the bottom. One section, the heaviest piece in the building, weighed nearly 32 tons; others weighed about 1,000 lb. per lineal foot and, although nearly as heavy as many of the girders, were handled by the single derrick booms.

In order to clear the railroad tracks, the basement columns were spaced 44 ft. apart on centers, a distance which, being unnecessary in the upper stories, was there diminished by intermediate columns carried on heavy girders and trusses of 44-ft. span.

Immediately over the track the floor was carried by 72-in. plate girders 44 ft. long and the heavy outer wall, self-supporting up to the main cornice, 80 ft. high, was carried on pairs of 84-in. girders 44-ft. long, that weighed about 18 tons each. In the postoffice floor there are 48x22-in. box girders 44 ft. long and lattice girders over 7 ft. deep, and between the third and fourth office floors there is a series of heavy triangular transverse trusses 12½ ft. deep which support the fifteen upper stories. The members of these trusses were shipped separately, assembled in position, and field-riveted there. All other columns and girders with maximum weights of over 30 tons each were completed, shop-riveted and erected as single units. The rivets in the field connections were driven by an ordinary force of six gangs of men, each operating a Chicago pneumatic hammer driven by compressed air received from the mains supplying the plant installed by the contractor for the excavation and other work in the terminal yard adjacent. The erection of the steel work was commenced by laying the grillages in July, 1906, and was substantially finished in March, 1907, with an average force of about 100 men.



Interior Court of Grand Central Office Building Showing Scaffold.

The first floor, at street level, was laid as soon as possible after the erection of the steel work had been carried above it, so as to afford a protection for the train service below. It was of the standard cinder concrete type proportioned for a live load of 365 lb. per square foot. To afford additional protection from possible falling objects all of the cinder floor in the Post Office department was covered with single 3-in. plank except in the city department, where it was doubled 3-in. planks. The floor of the pipe gallery below was protected by about 20,000 square feet of water-proofing. Besides this a temporary false roof of galvanized iron was built under a portion of the second floor, and special pains were taken in waterproofing and draining under the two concrete-mixing platforms.

All floors are of the Roebling flat-arch reinforced type and are independent of the ceiling construction, which will be of the suspended type. Beams, columns, girders and truss members are fire-proofed with cinder concrete 2-in. thick, reinforced with and laid on light steel-shapes, secured with standard clamps and hocks to the members, except the beam soffits, which are protected by ½-in. of cement mortar on metal lath. Wooden forms were built around the truss members, conforming closely to their cross-section, and the fire-proofing concrete was rammed within them to enclose all parts of the truss. About 11,000 yd. of 1:2:5 Atlas Portland cement concrete was required for the 432,000 sq. ft. of floor and roof surface and for fire-proofing the steel work. All concrete was mixed in two Foote machines made at Nunda, N. Y., each of them driven by a 10-h.p. General Electric motor. These machines were fitted with automatic screw feeds delivering without other measurements any required proportions of the materials to the mixing hopper where they were thoroughly incorporated together by a spiral mixer which carried them through the open trough and discharged them into a wheelbarrow below. Each machine had a capacity of about 175 yd. in 8 hr.

On account of the necessity of preserving the lower part of the building unobsructed for the train service, it was impossible to store sand, cement, cinders, brick and other material there, as is usually customary in such buildings, and the materials were unloaded and hoisted to the second floor, where they were stored and then rehandled as required. Concrete materials were elevated by a link belt conveyor to a small hopper in the top of the concrete tower whence they were automatically delivered by gravity to the automatic screw feed Separate General Electric motors were provided at each concrete machine to drive the elevators and a small crusher designed by the Roebling Construction Co. installed there to break up any large lumps of slag to a maximum size of 1 in. The concrete was discharged from the machine into wheelbarrows which were lifted in pairs by two platform elevators designed by the Roebling Construction Co., and built by the Lidgerwood Mfg. Co. Four other platform elevators were installed at equidistant points in the building to handle other materials. Two of them were made by the Lidgerwood Mfg. Co., one by the Maine Electric Co., and one, operated by steam, was made by the American Hoist & Derrick Co.

The cut stone in the exterior walls includes about 62,000 ft. of Indiana limestone and 15,000 cu. ft. of granite from the quarries of the Stony Creek Granite Co., Conn. This stone was partly stored on the ground and partly on the sidewalk bridge alongside the building, and was handled entirely by four boom derricks seated on the roof and operated by Lidgerwood steam engines. The heaviest pieces weigh about 7 tons each and were carefully anchored to and generally supported directly from the steel framework. All of the window frames are made of cast-iron or bronze and were very carefully set before the stone work was built around them, the joints being afterward calked with oakum and putty. Almost as soon as the masonry work was commenced it was interrupted by a strike, which delayed it for nine months, so that effective operations on it were not begun until May 15, since when about 60,000 cu. ft. have been laid and the work is now rapidly progressing.

The cut stone is laid from the inside of the building but the brick face walls of the interior courts are built from outside scaffolds; part of these are of ordinary construction, supported on cantilever beams, but forty of them are patent scaffolds made by the Wm. Murray Co., New York. Each of the latter is about 5 ft. wide and 9 ft. long, with longitudinal floor boards laid on transverse pairs of 2x1½-in. angles, back to back, with vertical connection irons between their web. These connections project above the top flanges and receive small cast-iron drums fitted with worm-gears operated by detachable cranks.

Each scaffold has four drums and each drum has 100 ft. of ½-in. wire rope made fast at the upper end to 8-in. horizontal cantilever I-beams about 20 ft. long, projecting over the edge of the roof and anchored to it at their inner end. Stirrups enclosing the outer ends of the I-beams take bearing on their top flanges and have horizontal bolts through their projecting lower ends to receive the loops at the upper ends of the suspension rope. These platforms can be rapidly and evenly lifted by the brick layers so as to keep them always at the level most convenient for effective work. They have been found very convenient and efficient on this work and on other jobs where they have been used by the same contractor. About 250,000 pressed brick are required for the court walls and are backed up with ordinary red brick, 1,800,000 of which are required for that portion of the building now under contract. In the sixth story a buzz saw and an emery wheel driven by a 5-h.p. General Electric motor were installed and at each end of the building a broad temporary staircase with hand rails was built for the use of the workmen and was believed to have effected a considerable economy in saving time.

The average total force of about 350 men employed by the general contractor is under the direction of Mr. E. F. Dodson, superintendent. The steel work was fabricated and erected by the McClintic-Marshall Co. The work is designed and constructed under Mr. W. F. Wilgus, Vice-president of the New York Central & Hudson River R. R. Co., by Messrs. Reed & Stem and Messrs. Warren & Wetmore, asociated architects. Mr. Chas. A. Reed, Executive, and Mr. H. G. Balcom in charge of steel work and structural designs.

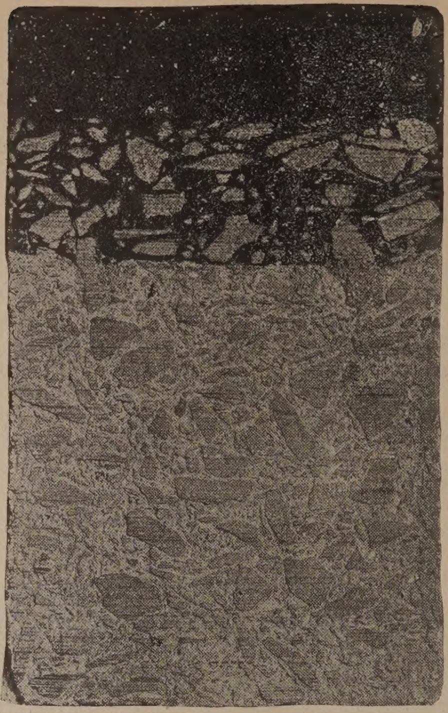
THE VALUE OF LAND taken for water works purposes, according to the Massachusetts Supreme Judicial Court in Sargent *v.* Town of Merrimac, 81 N. E. Rep. 970, is made up of the value of the land, apart from its special adaptability for water supply purposes, plus such sum as a purchaser would add to that value on the chance that the land might be some day used as a water supply.

The Asphalt Pavement on the Thames Embankment.

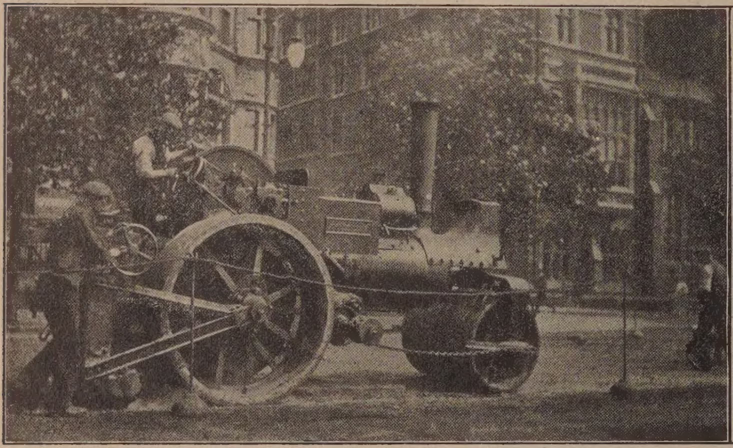
One of the most interesting pieces of pavement laid of late is the sheet asphalt work done on the Thames embankment at London. For a number of years an attempt was made to keep the roadway on this street in a satisfactory condition with macadam. It was believed that this would make the carriageway more agreeable, owing to freedom from noise, but the macadam has been a failure mainly on account of lack of durability and somewhat owing to dust. The street is one of the highest class in London and it was felt that the best type of pavement was warranted for it. Sheet asphalt was not regarded with particular favor in London, but the excellent results attained with it elsewhere finally led the authorities to award a contract to the Trinidad Lake Asphalt Paving Co., Ltd., for the work.

The macadam of the Thames embankment is of great depth, and it was accordingly decided that the best pavement to try would be one with about 3 in. of a very close binder, laid on top of the old macadam, and then a wearing surface suited for the character of the traffic. The old surface was accordingly graded down to a depth of 9 in. by means of a scarifier attached to a road roller in the manner shown in an accompanying illustration. The material loosened in this way was removed with wheelbarrows and when the full depth of 9 in. had been taken off the surface was very carefully brought to grade. Owing to the compacting of the material under long traffic the portion remaining was in a hard, dense condition.

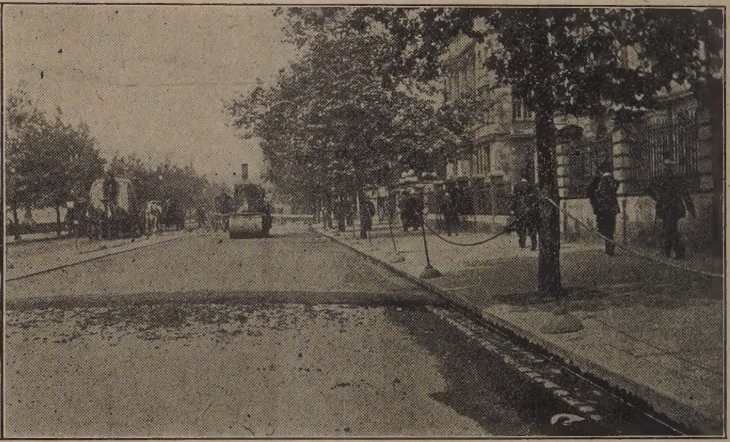
The most interesting feature of the work was the very thick course of close binder. This course is different from the open binder course used on many asphalt pavements in America, which has generally not been dense or strong enough, owing to voids and the use of unsuitable stone to carry a heavy traffic, and has been a source of weakness in consequence. The improved binder which is being introduced where the local authorities can be persuaded to pay for it consists of the same grade of stone as the old binder, but with the voids completely filled with the fine mixture used for the surface coat. With a mixture of such composition, well cemented with a bituminous cement, a perfectly stable course is obtained between the foundation and the surface, which is capable of sustaining the latter under any travel to which it may be subjected, without the slightest vibration.



Pavement for Heavy Travel.



Method of Loosening Old Macadam.



Close Binder Ready for Surface Mixture.

Placing Surface Mixture on Binder.

The Thames Embankment Pavement.

The surface mixture was placed on the binder and rolled down in the customary way in this country, as shown in one of the accompanying illustrations. The pavement now has been exposed to wear for about a year, and its appearance and the class of traffic to which it is subjected are well shown in one of the illustrations

In a paper by Mr. Clifford Richardson which was printed in this journal on June 1, attention was called by the author to what he considered the best type of sheet asphalt pavement for use on the streets having continuous heavy travel. The accompanying illustration gives a cross section of such a piece of pavement. Mr. Richardson considers that for such service a Portland cement concrete base at least 6 in. thick is necessary, and an even thicker foundation if the sub-soil is not of the firmest character. Under ordinary circumstances 6 in. of foundation is believed to be enough if it is constructed with a high-grade Portland cement and good hard stone, for which good gravel may be substituted in many instances. It is believed that every effort should also be made to provide proper drainage of the base.

Upon such a base Mr. Richardson advises the use of 2 in. of close binder, like that used in the Thames embankment pavement, and shown in the accompanying cross section. The stone for this binder should be hard enough to carry the travel without crushing. On this binder should be laid a wearing surface of standard grading made with a cement consisting of a mixture of suitable bitumens skillfully combined and handled. This surface should be 1 1-2 in. thick, and a thicker surface is unnecessary, if the work is done carefully and the materials are suitable, because the rigid character of the support makes it unnecessary for the top to be anything but a true wearing course. If an open binder course and poor foundations have been laid, than a wearing coat 2 in. thick is necessary.

The Pumping Plant at Milton-Royal.

The water pumping plant at Milton-Royal, England, is rather interesting on account of the use of two 20-h.p. Diesel engines for operating the triplex pumps which raise water from a pair of wells to a reservoir, the total height overcome being about 177 ft. Although the engineers are not normally required to do so, they will start the pumps against the full head of the reservoir readily. An automatic device has been provided for stopping the engines when the reservoir is full. Adirect-acting balanced float regulator is fixed in the reservoir at the head of the delivery main. The float is placed in a separate cast-iron chamber which has only a small opening into the reservoir to ensure perfectly steady motion of the float. When pumping is in progress, and the water in the reservoir has run to within an inch of its top-water level, the regulator commences to close, and gradually increases the pressure in the delivery main until the relief-valve in the pumping station opens automatically. Underneath the discharge-pipe of the relief-valve a copper bucket is suspended at the opposite end of a counterbalanced lever. When the bucket fills, it raises the counterbalance and in so doing closes the oil-cocks upon the pipes supplying fuel to the engines, which stop in about one minute. The water in the bucket then runs out at a small hole, and the bucket returns to its original position for the next automatic stop. The float regulator is set with a minimum opening sufficient to create a maximum back-pressure of about 50 ft. in the rising main when both engines are running, if the bucket is forcibly prevented from falling. The apparatus prevents the water from being run to waste at the reservoir unknown to the attendant, and allows him to be absent from the pumping-station for short intervals. The present practice is to run a set of engines and pumps every day until it stops automatically; one set being used one day, the other the next. This practice allows careful daily inspection of the machinery at rest, and of any repairs that may require but a short time.

Atlantic City Sewer Construction.

The sewer system at Atlantic City, N. J., was installed by a private company to serve a population which varies from about 40,000 in winter to over 400,000 in summer and at present has about 9,000 buildings connected, among which are many hotels, some of them of large size. As the surface of the ground is very flat and its elevation varies from 0 to 6 ft. above high-tide level, the grades of the sewers are necessarily kept very low and very careful design and accurate construction are necessary to secure a gravity flow, which, in some cases, is combined with pumping to the outlet. As the growth of the city is constant and rapid, corresponding extensions and improvements of the sewage system are continually in progress, which have varied in cost from $50,000 to $100,000 annually for several years.

Driving Wooden Sheeting with Hydraulic Jet.

Driving Steel Cofferdam Sheeting with Jet.

The work under construction this season includes 4,600 ft. of intercepting mains receivlng the gravity flow of one district and a pump well 20 ft. deep and 25 ft. in interior diameter into which they discharge. This well is intended merely to connect the gravity and pumping systems, and is not designed to provide storage, as the sewage is pumped by centrifugal pumps to the outfall through a 16-in. and a 24-in. cast-iron pipe about 2 miles long. The well is located in very fine sand containing large quantities of ground water up to a level about 4 ft. below the surface. Its site was first enclosed by a circular cofferdam 33 ft. in diameter made with 12-in. 35-lb. United States sheet piles about 26 ft. long. Ninety of these, handled by a center boom derrick, were driven in three days with a single hydraulic jet, sometimes assisted slightly by a steam hammer.

Excavation inside the cofferdam was made by hand, the sand being shoveled out over the tops of the piles until the pit was about 8 ft. deep, after which a portion of it was shoveled on to platforms and thence reshoveled over the tops of the piles in order to continue the work while waiting for the installation of a Carson-Lidgerwood cableway of 300-ft. span, which is also to be used for the excavation of the sewer trench. The interior of the cofferdam is braced by successive tiers of horizontal rangers from 5 ft. apart at the top to 3 ft. at the bottom. These rangers are made of 10x10-in. timber, in lengths of about 6 ft., with their ends cut radial so as to fit together and make accurate polygonal rings exerting balanced reactions and forming horizontal arches in equilibrium, which resist the external pressure without any transverse or radial bracing, thus leaving the entire area of the cofferdam unobstructed. At each joint the rangers are securely spliced together between top and bottom steel plates ¼ in. thick and about 24 in. long, secured to both timbers with vertical ¾-in. bolts. As the sheet piles were driven several feet below the bottom of the excavation they form a sort of core wall which intercepts the flow of the ground water and enables the excavation to be kept dry by a single 3½-in. pulsometer working in a sump which also drains a short length of the trench excavated for the connecting sewer mains.

After the excavation is completed, about 200 piles 12 ft. long will be driven in its bottom and cut off below grade. They are arranged about 25 in. apart in concentric circles 25 in. apart and are capped with circumferential 3x10-in. timbers on which is laid a continuous tight floor covered with 2 ft. of 1:3:5: concrete made with Atlas Portland cement and 1½-in. broken trap rock. A six-ply felt and tar waterproofing is built into the concrete 3 in. above the bottom and extends continuously through the vertical cylindrical walls of the well to the surface of the ground. The upper portion of the concrete floor is reinforced by horizontal and transverse rods ½ in. square from 4 in. apart at the center to 8¾ in. apart at the circumference. The walls are made of unreinforced concrete 28 in. thick at the foot and support the pump room floor 10 ft. above the center of the bottom. The floor is made with a continuous 6-in. slab of concrete reinforced by two layers of expanded metal and supported in the center by a single 12x24-in. transverse girder with four 1-in. square reinforcement rods in its lower flange. A concrete roof similar to the floor construction will be supported on the tops of the walls.

The pump well has two inlets, one 36 in. in diameter connecting it to the old well, and the other 66 in. in diameter connected with a reinforced-concrete pipe 66 in. in diameter inside, which is 600 ft. long and intersects at the opposite end the similar 4,000-ft. line of new 54-in. intercepting sewer. All of the pipe is cast in steel molds near the site in sections 3 ft. long with male and female ends. The 66-in. pipe is 6½ in. thick and is reinforced with seven ¾x3/16-in. longitudinal bars and three 2x⅛-in. hoops, interlocking with them. Each hoop is cut so that the middle portion of the steel can be sprung out, forming loops engaging the longitudinal bars. The ends of the longitudinal bars project beyond the ends of the concrete sections and are bent back 180 degrees to form hooks overlapping each other and securely locked together by circumferential bars threaded through them after adjacent sections of the pipe are assembled together.

The pipe is cast vertically in molds, each with an annular cast-iron bottom ring forming the female joints and receiving the inside and outside walls of the mold. Each wall is made with four segmental cylindrical pieces of ⅛-in. steel connected together with top and bottom latches. The inner wall is secured at the bottom by an adjustable spider made with two horizontal ¾-in. pipe arms intersecting each other at right angles and terminating at their outer extremities with cross heads, each of them carrying two horizontal set screws for adjustment. The top of the wall is stiffened by an inside welded steel ring. The outer wall is braced in position by small separators engaging the inner wall, and the longitudinal reinforcement bars are set vertically with their lower ends engaged in sockets in the annular base plates and their upper ends fixed by the separating pieces.

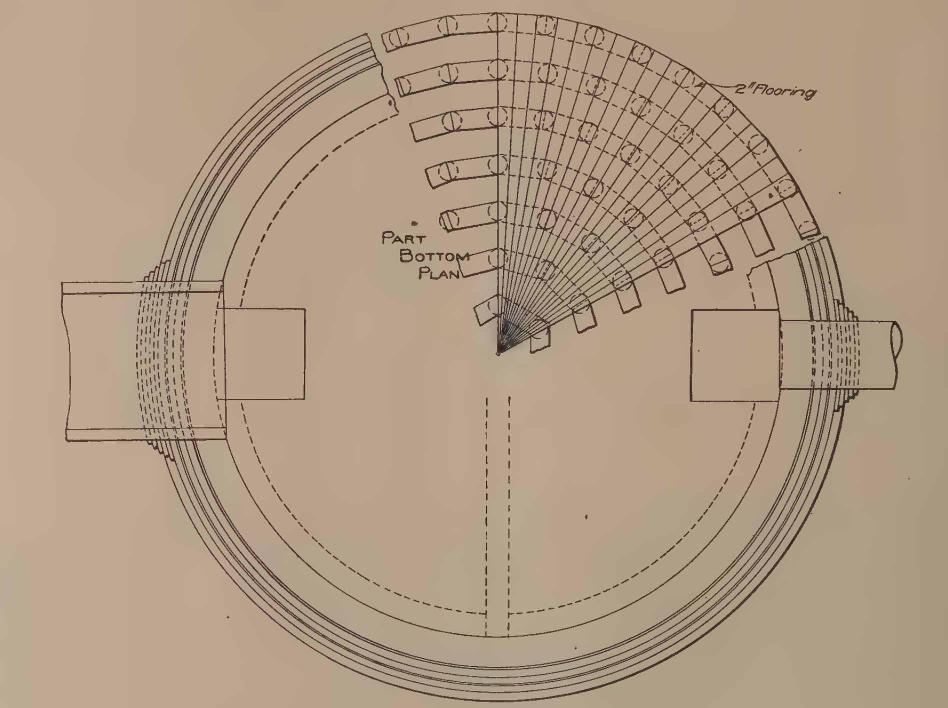
Small quantities of very dry concrete are placed in the mold and rammed until the water flushes well on top. When the mold is about one-third filled, the first ring is slipped down, engaging the longitudinal bars, more concrete is added and rammed, the second ring is inserted and finally the concrete is filled in to the top of the mold. All portions of it are thoroughly rammed with steel rammers weighing about 12 lb. and curved to fit the circumference of the pipe and nearly close the annular space between the walls. These rammers are about 12 in. long and their ends are slotted to engage closely the longitudinal bars and insure ramming both sides of them. After the mold is filled a special cast-iron top ring is set on it and filled with concrete to form the male end of the joint. As soon as this is well rammed the ring is removed and the pipe section left standing until the next morning when the mold is stripped from it and used for other sections. Each 3-ft. section of 66-in. pipe weighs about 4,000 lb. and contains 1 1/7 cu. yd. of concrete made with Lehigh cement and ¼ in. clean gravel. In this case the concrete is hand mixed and is made in proportions of 1:2:4, but when machine-mixed proportions of 1:2½:5 are found satisfactory. Ten complete molds were provided, and with them 10 sections of pipe daily are made with a gang of 12 men and superintendent.

The pipes were rolled along the trench and lowered to position by derricks and the stresses thus occasioned were considered to test them sufficiently, although they were subjected to very rigid surface inspection. One section of pipe only a few days old was struck by a heavy truck and the only injury it sustained was chipping off a few cubic inches of concrete on one edge, which can be easily patched, while the truck itself was seriously damaged. When the pipe sections are laid in the trench, their male and female ends are properly engaged, circular strips are threaded between the overlapping hooks of the longitudinal reinforcement bars at the joints, the inside of the joint is pointed with 1:1 cement mortar, the exterior is covered with a galvanized iron strip bolted in place over a canvas gasket, and the joint is filled with grout poured on the top of the pipe. This develops sufficient pressure to produce leaks if any weak places exist and these are immediately noted by the inspectors and corrected while the joint is being made so that it eventually makes a smooth, tight, strong connection between the successive lengths of pipes.

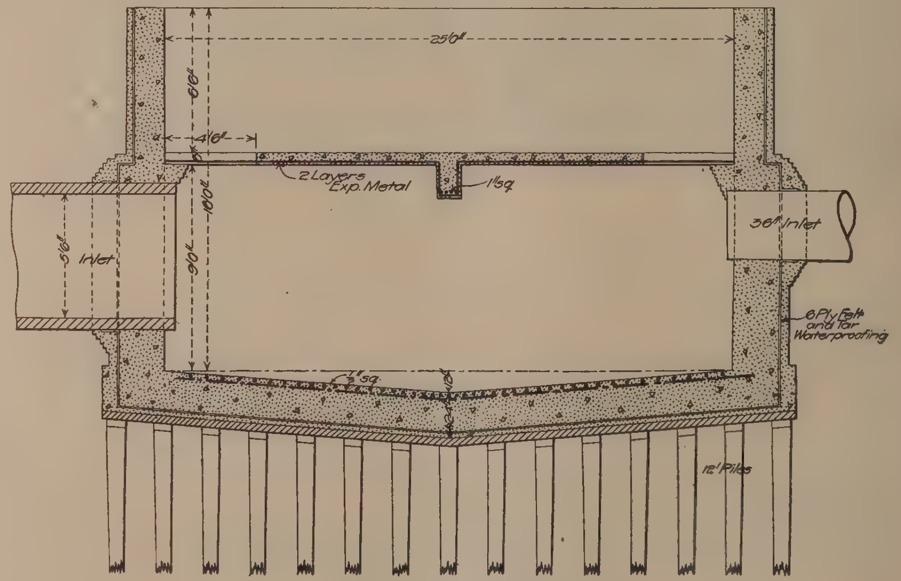
The trench for the 66-in. pipe is 9 ft. wide and 14 ft. deep, and is sheeted with 2x12-in. planks driven with a water jet at about 65 lb. pressure delivered through a 2½-in. pipe and a 1-in. nozzle. The edges of the planks are rabbeted 2½ in. to make a ship plank lap joint, which gives good satisfaction in this soil, composed of fine sand or quicksand. The trench is excavated to a depth of about 2 ft., and in it are assembled the 8x8-in. rangers or waling pieces and cross braces framed together with splice plates and blocked up to the level of the surface of the ground. The piles are rapidly driven outside them with the hydraulic jet, aided by occasional raps with a sledge hammer, and rapidly penetrate their full length of 18 ft., after which the excavation is completed and successive lines of rangers are framed in as the pit is finished. After the completion of the trench the pipe handled by the cableway is laid and jointed at the rate of about 22 sections per day by about 5 men.

Sections of similar pipe 42 in. diameter inside and 4½ in. thick were jointed together and placed on supports 8 ft. 3 in. apart on centers and tested by bending loads of 16,500 lb. uniformly distributed, which did not produce observable deflection. A deflection of ¼ in. was produced by a load of 17,500 lb., the first crack appeared with a load of 21,700 lb., and the pipes finally collapsed with a load of 28,320 lb. Three sections of 36-in. pipe jointed together were subjected to hydraulic pressure of 40 lb. per square inch which did not cause destruction but developed a longitudinal crack in one pipe.

The Atlantic Construction & Supply Co., Mr. J. H. Decker, chief engineer, is the designer and contractor for the work here described. The reinforced pipe is made by the Reinforced Concrete Pipe Co., Jackson, Mich., Mr. G. E. Johnston, superintendent.



Top Plan



Concrete Pump Well.

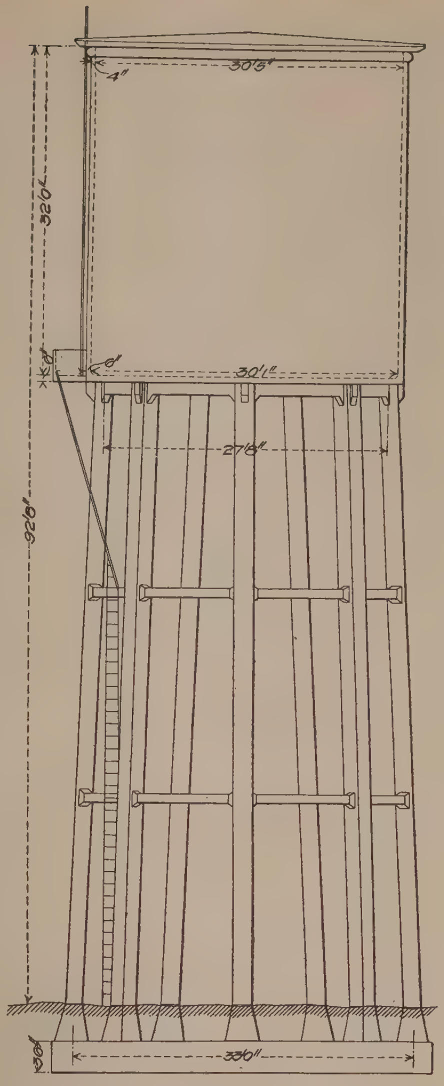
The Recovery of Brass in San Francisco has been carried on by interesting methods during the past few months on the site where the brass foundry of W. T. Garrett & Co. stood before the fire of April, 1906. At the time of the fire three stories of the building were filled with finished brass goods and the metal, melted by the heat, ran into the basement. Some of it has been recovered in large masses, some by screening the earth and debris, and some by hydraulic sluicing over riffles.

A Reinforced Concrete Water Tower at Anaheim.

In reconstructing the water works for the city of Anaheim, in southern California, the problem of a structure for an elevated water supply was one that had to be solved, the immediately surrounding country being very level with no natural reservoir site available. The population supplied is about 3,500 and it was necessary to have a storage capacity of 175,000 gal. with a minimum head of about 60 ft. Bids were called for upon specifications for an elevated hemispherical-bottom steel tank on steel towers and for a tank and tower of monolithic reinforced concrete construction. The specificatons for the concrete tanks required that bidders must be able to show successful examples of reinforced concrete construction either of tanks or stacks, or structures of a similar nature.

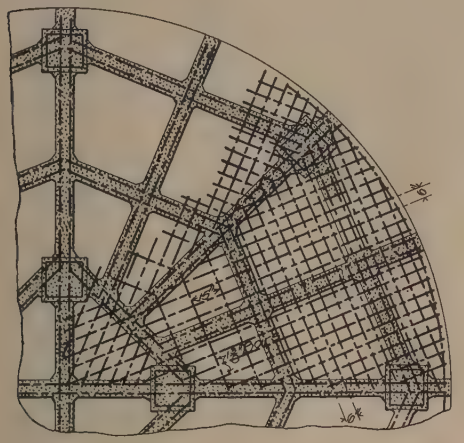
The bids for steel tanks and towers ranged from $9,200 to $12,500, while for the reinforced concrete tank and towers two bids were received, one for $10,400, which was accepted, and the other much higher. The greater durability, reduced cost of maintenance and better appearance led the city trustees to accept the reinforced concrete structure.

The specifications under which the contract was let required the contractor to furnish his own detail drawings and to give a complete description of his method of construction, but allowed considerable latitude in the kind of reinforcement and even in the plans for the structure, subject, of course, to the approval of the city. In the plans and specifications as prepared by the contractor, the design submitted by the city is closely followed, although the contractor elected to reduce the amount of concrete in some parts of the structure, to increase its richness and also to make some other slight changes.

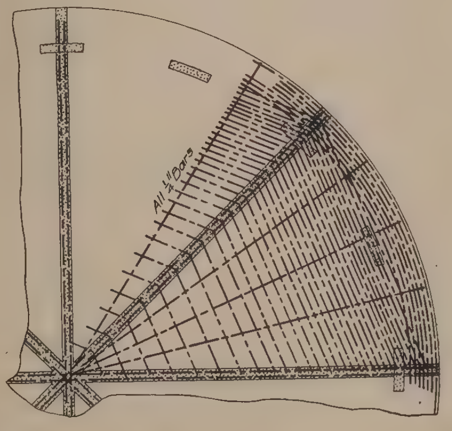


Reinforced Concrete Water Tower.

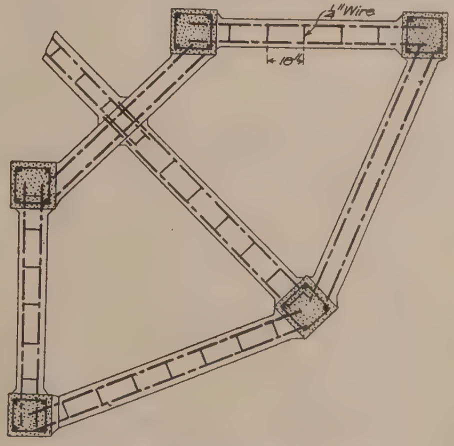
The tank is approximately 30 ft. 3 in. in diameter and has a clear interior depth of 32 ft. It rests on twelve reinforced concrete columns, each 22 in. square and 60 ft. 2 in. long, eight of them being placed equidistantly on the circumference of a 33-ft. circle and the other four on the circumference of a 4-ft. 4-in. circle. The columns are braced by two series of horizontal struts at the third points of the length of the columns, but no diagonal bracing in vertical planes is used. The batter of the columns and the manner in which they are built into the foundation slab and the tank floor are intended to provide for the lack of diagonal bracing. The horizontal struts evidently contribute in the rigidity of the tower by dividing the columns in effect into three compression members.



Floor and Girders at Bottom of Tank.



Roof Reinforcment.



Horizontal Strut Reinforcement.

The soil at Anaheim is an alluvial deposit underlaid with strata of sand to a depth of 50 ft. and in periods of great rains these strata are said to resemble quicksand. This led to the adoption of a very conservative foundation bearing pressure. Holes sunk near the location showed that the first stratum of sand was about 8 ft. below the surface. The excavation is carried down 6 ft., and in case sand should be encountered at that depth it is to be removed for 18 in. and replaced with soil or clay.

The reinforcement consists throughout of twisted square steel bars tied together where necessary with ¼-in. round iron. The steel is to have an elastic limit of about 40,000 lb. per square inch before twisting and about 60,000 lb. after twisting, and an ultimate strength of 80,000 lb. Extra care is required in placing the steel in its proper position and especially to prevent any movement of the reinforcement while concrete is being placed. All joints between adjacent continuous rods in tension are to be lapped 12 in. and bound together by wrapping with soft steel wire.

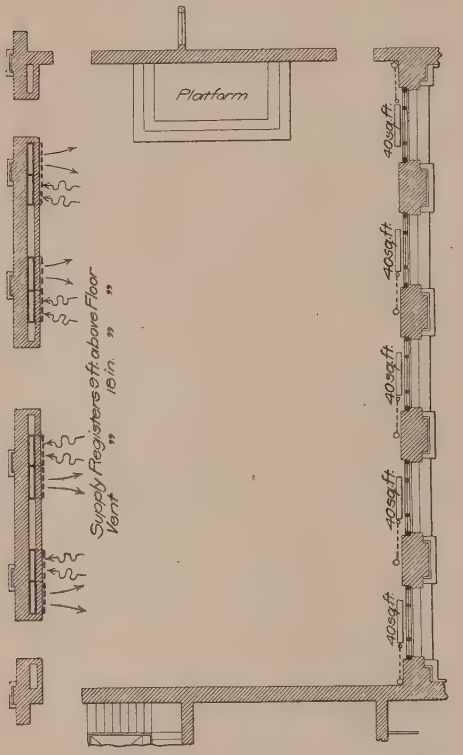
The foundation consists of a reinforced concrete slab 36 in. thick and 37 ft. square, extending out beyond the limits of the tower and tank on all sides. It is made of 1:3:4½ concrete, the crushed rock or gravel varying in size from ¼ to 3 in. in largest dimension, and is reinforced by twisted steel bars placed 2 in. from the underside of the slab. The bottom bars are of ⅞-in. material, 16 in. on centers and at right angles to them are placed the distribution bars of ¾-in. material, 12 in. on centers. On top of this foundation slab are built the pyramidal pedestals of the columns which are anchored to the slab by means of the twisted steel bars running through them and imbedded in the concrete of the foundation. The columns are reinforced with four ¾-in. twisted bars, one in each corner, tied together with ¼-in. iron wire. When the tank is empty the assumed wind pressure is sufficient to cause tension in the columns and the vertical reinforcing in the latter is therefore designed to resist both compression and tension. The ends of adjacent rods are kept in line by being placed in a socket about 12 in. long, and in order to resist tension are joined by a splicing bar of twisted square steel about 48 in. long, firmly bound to them with soft steel wire. The columns and girders are made of 1:2½:2½ concrete, using the run of the crusher under ¾ in. for the stone.

The struts have a cross-section 14x16 in. and are reinforced with four twisted bars either ½-in. or ⅝-in. material, one being placed in each corner and tied together, as explained for the columns. By far the most complicated part of the reinforcement consists in the beams and girders supporting the floor of the tank. Most of these beams and girders are 8 in. wide, varying in depth from 12 to 16 in. The placing of the reinforcement in them does not differ from the standard methods except that the stirrups of ¼-in. wires are used quite plentifully. The floor of the tank is 6 in. thick, reinforced with ⅜-in. bars placed with varying centers according to the span, the greater part of them being placed in a right angled grid on 6-in. centers both ways.

The sides of the tank vary in thickness from 6 in. at the bottom to 4 in. at the top and, like the floor, are made of 1:2:2 concrete, the stone being the run of the crusher under ½ in. In case the rock should vary to such an extent as to give a more dense concrete if mixed in some other proportion the amount of sand and rock will be varied accordingly. The reinforcement of the sides consist of ¼-in. twisted steel bars placed vertically on 24-in. centers around the circumference of the tank, running from the floor to the roof, across which laid horizontally and continuously around the tank as a hoop are ¾-in.

twisted steel bars with centers varying from 3½ to 12 in. For the lower half of the height of the tank these hoop bars are ¾-in. steel, for the next 5 ft. of ⅝-in. steel, and for the remainder of the height of ½-in. steel. The spacing of the ¾-in. bars varies from 3½ to 7 in., of the ⅝-in. bars from 5 to 7 in., and of the ½-in. bars from 5 to 12 in., the smaller spacing, of course, being used in the lower part of the section containing a given size bar.

The roof is a flat cone having a rise of only 12 in., and is carried by 8 radial reinforced concrete girders, varying in depth from 9 to 15 in. The roof is 2 in. thick reinforced with ¼-in. twisted steel rods laid both radially and perpendicular to the radii, the latter bars reaching between the girders which support the roof. The spacing of the bars laid crosswise of the radial ones varies from 3 in. near the edge of the tank, where the span between the girders is longest, to 12 in. near the center, where the span is very short. A steel ladder allows access from the ground to the tank.



Systems in Board of Works Meeting Room.

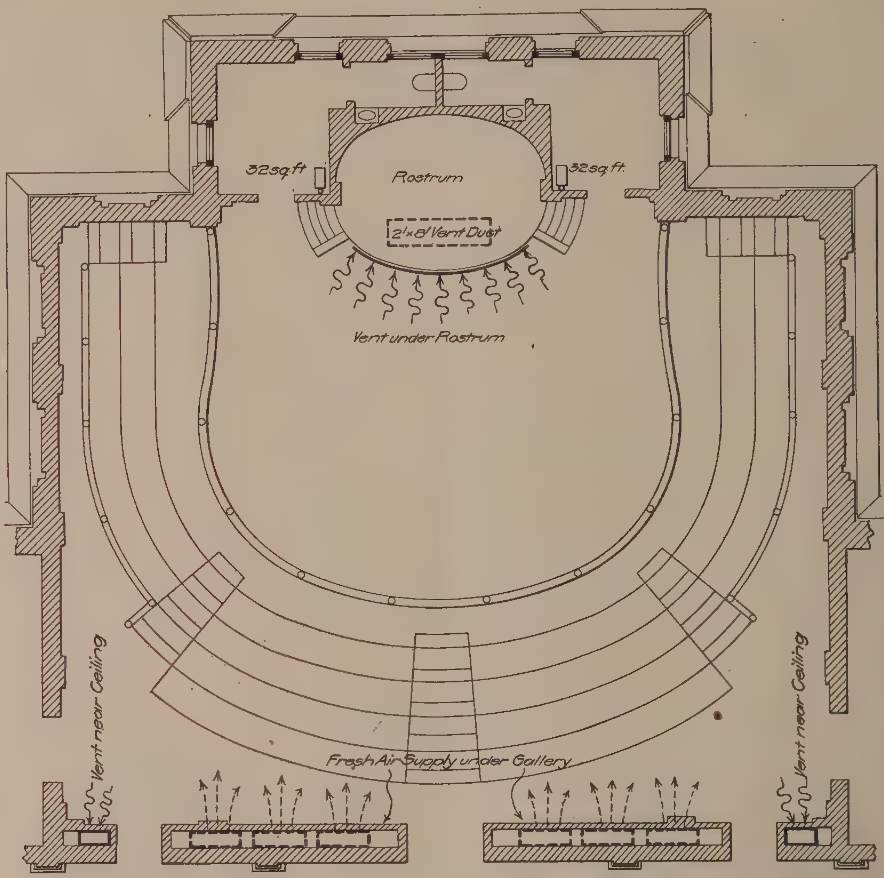
The water-proofing of the tank is considered the most particular part of the work. Every effort will be made to prevent lack of continuity in the walls due to cessation of work from day to day. The inside of the tank is to receive a water-proofing coat, ½ in. thick, composed of 1:1 cement grout. Of the cement used 96 per cent. must pass a 100 mesh screen and 82 per cent. a 200 mesh screen. The contractors will also use some astringent to aid the water-proofing. The specifications require the contractor to keep the tank filled with water for ten days before acceptance, during which time it must not develop any structural weakness nor any objectionable leakage.

The structure was designed by Mr. F. R. Schanck, of Messrs. Clem A. Copeland & F. R. Schanck, consulting engineers, Los Angeles, who have designed and have charge of the rebuilding of the municipal lighting plant and the water works of the city of Anaheim, of which Mr. A. L. Lewis is superintendent. The contractor is Mr. Carl Leonardt, Los Angeles, Cal., the plans being those of Mr. T. F. Osborn, engineer for the contractor.

Mechanical Plant of the New City Hall, at Newark, N. J.—Part II.

Heating System.—The heating system of the new City Hall is a combination of direct radiation and hot blast operated with the exhaust from the steam-using machinery of the power plant, with make-up of live steam supplied automatically when the exhaust steam supply is insufficient. The radiation is in general connected on the single pipe system, with the exception of the indirect radiation which is supplied on the two-pipe system. The heating in a large part of the building is independent of ventilation, but in a number of the larger rooms used by many people the direct radiation is supplemented by indirect heating. The radiation throughout is operated with gravity return, but is in all parts of the building under automatic thermostatic control. An interesting feature of this installation is the use of an air line with novel exhaust, which connects the air valves on all radiators into a header in the sub-basement that extends across to the boiler house and up to an outlet inside of the chimney near the top, the purpose of the latter connection being to remove all air and vapor from the radiators freely by induced draft.

The radiation is distributed in the usual arrangement under window sills for counteracting window glass exposure, the heating surfaces of the units being proportioned on the thermal unit basis of heat loss from the building. The arrangement is such that there is a radiator unit under every window in all rooms to be heated, except in certain small rooms and store rooms which are not occupied. Even in rooms which are fitted for fresh air supply with indirect heating, the usual window-sill radiator arrangement is maintained, and in a number of the larger offices, radiators are installed on the inner walls to provide for additional heating or to counteract possible cool drafts from the corridors. In the Common Council chamber which has no side window lighting but dome sky-lighting only, there are no radiators installed, indirect heating being depended upon entirely. The interior court spaces within the corridors, which are similarly lighted by sky-lights, are heated in general by radiator units distributed at the basement corridor level, while the sky-light glass exposure is counteracted by hot blast delivery from the indirect heating system, which is directed upward toward the sky-light so as to diffuse with and counteract the cool descending currents of air. In the rear wing of the basement, however, there are two court-rooms which, although having side window lighting, are heated entirely by the indirect system, there being no radiators installed in the rooms.



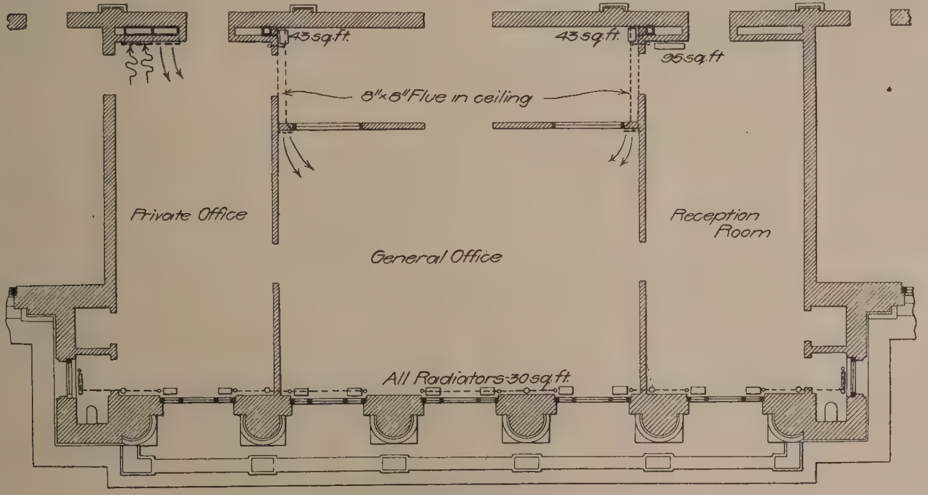
Ventilation of the Council Chamber, Newark City Hall.

The radiation installed is of the cast-iron construction throughout the entire building, including the tempering coils and reheaters of the ventilating systems, that for direct radiation being for the greater part of the Classic form in both the single and double column patterns and in heights of 31 and 38 in., according to the window-sill clearances. The reheater coils are of the Losee pattern and are installed in the duct connections of the fresh air supply system in the sub-basement as will be referred to in connection with the ventilating equipment. The latter radiators are under the direct control of the thermostats which control the direct radiation for the corresponding rooms supplied and are thus essentially a part of the heating system. The amounts of heating surface installed in the various sections of the building are given in the accompanying table.

Steam is supplied to the direct radiation from the sub-basement by 64 riser lines, which range in size from 1½ to 4 in. and supply from 1 to 8 radiator units each. Forty-three of these rise direct to the top floor of the building, 5 to the 3d floor, 6 to the 2d floor and the remainder to radiation on the 1st floor, all of the lines decreasing in size as the radiator branches are taken off. All of the lines are anchored on the second floor level, each anchorage consisting of a short nipple connected into the pipe between two couplings, a strap anchor being clamped onto the nipple to prevent the pipe from settling. All branches to the radiators as well as also the air line connections are imbedded in the floor construction with due allowance made for expansion both upward and downward from the 2d floor anchorage point. All risers are fitted with cut-off valves just below the sub-basement ceiling, below which connections are made to branches of the heat distributing mains. Each of the risers is dripped at its base into the condensation return system which has mains and branches paralleling those for the low pressure steam distribution to all parts of the sub-basement; the drip connections are all large in size, having carrying capacities equal to approximately one-half that of the risers, and the drainage is all by gravity. The system of air lines through which air and vapor is drawn from the air valves on all radiators, corresponds exactly to that for steam supply to the radiation, the risers and branches to radiators duplicating exactly those for steam supply with the exception of size, the arrangement and proportion being approximately the same.

Newark City Hall Heating Equipment.

Portion Heated.	Number of Radiators.	Total Heating Surface, Sq. Ft.	Thermostatic Valves.	Thermostats.	Indirect Number of Stacks.	Total Heating Surface
Main Floor.....	64	4,809	83	29	13	2,540
Second Floor....	79	3,971	100	44	14	3,190
Third Floor....	59	4,278	56	43		
Fourth Floor....	52	4,290	52	15		
Basement and Corridor.	73	5,561	72	39	5	1,220
Main Rotunda..			8	2	4	3,200
Total	327	22,909	371	172	36	10,150



Heating and Ventilation of the Mayor's Office.

The heating supply system originates in the exhaust steam header in the power plant division of the sub-basement as referred to in the article in the previous issue. This header is a 16-in. exhaust line which connects through a grease extractor first to a 10-in. atmospheric exhaust outlet that leads to the boiler house exhaust head and thence through a gate valve to the heat distributing mains. Beyond the gate valve there is a live steam make-up supply connection through which live steam is added to the heating system when the exhaust from the steam using machinery is insufficient; the latter consists of a 6x8-in. Foster reducing valve which is capable of reducing the pressure from 90 lb. to 1 lb. and this is fitted with a 4-in. bypass for hand operation if necessary. The heating system header is a 12-in. steam line with four branches to the four corner sections of the building, those to the front corners being 8-in. and those to the rear are 10-in. lines. From the end of the heating main, an additional 4-in. line is extended to the fresh air supply fan room in the rear corner of the sub-basement to supply the tempering coils. Branch lines from these mains extend to all parts of the sub-basement to supply risers, decreasing in size as supply connections are taken off and they are graded with the flow of steam, condensation being drained out through the drip connections at the bases of all risers supplied.

The condensation return system parallels that for low pressure steam distribution in the sub-basement in general; the drainage connections at the bases of the risers and also those from the tempering and reheater coils of the fresh air supply system, delivering into a series of mains which conduct the condensation to a tank depressed in a pit in the westerly portion of the sub-basement. These mains are like the steam mains, arranged in four divisions, which extend to the four corners of the sub-basement to connect with the various apparatus and risers. The condensation receiving tank is a 3x8-ft. steel cylindrical tank which is located in the pit so that it is entirely below the sub-basement floor level, and the condensation gathering mains deliver into this in two groups, each through a 6-in. connection with return seal.

The condensation tank pit is about 3 ft. deep and 13x16 ft. in size in order to accommodate the return pumps on a level below that of the tank and thus facilitate the handling of the hot returns. These pumps are 7½x4½x10-in. Worthington duplex pumps which return the condensation, under control of a Kieley pump governor on the condensation return tank, to the boiler house for use in the boilers, as referred to in the preceding article upon the power plant of the City Hall. On account of the low level of this condensation tank, the condensation drains freely from the radiation both direct and indirect, and is delivered to the boiler house for boiler feeding as rapidly as it accumulates. The return of condensation is also facilitated by air line systems, which consists of a piping system with ⅜-in. connections to the air valves of all radiation, all of which connect into a 3-in. vapor header in the sub-basement that extends to the boiler house and up to an outlet within the sack near the top to effect an induce draft; the very srong draft of the stack induces a strong exhaust to these vapor lines and is found to be very effective in removing air and vapor from the heating system mains. All of the piping in connection with the heating system, both for low pressure steam supply and return, is covered with H. W. Johns fire felt applied to a thickness of 1½ in. and enclosed in canvas jacketing.

Ventilation.—While the City Hall building is situated on a spacious grounds and has ample corridor spaces within, which are the conditions most favorable for natural ventilation of a building, artificial ventilation has been provided for in a number of the public and more extensively occupied portions. These include the Common Council chamber, the Board of Works meeting room, the court-rooms in the basement, the Mayor's office and some of the large and much frequented offices. In certain of these, notably the Common Council chamber and the court-rooms, the fresh air supply system is depended upon solely for heating, while in the remaining portions fitted for mechanical ventilation, the indirect heating is supplemented by radiators which are so placed as to counteract window glass exposure, and accomplish partial heating if the indirect systems be shut down. Ample changes of air are provided for in all of the ventilated portions to provide for maximum conditions of occupancy so that, with the profuse ventilation that has been provided in the corridors and interior court area, a very satisfactory and effective ventilation of the entire interior of the building is secured. The equipment also includes two independent exhaust systems for the groups of toilet rooms in either end of the building and air filters of the cheese cloth type for the fresh air supply. An unusual feature of the installation is the use of a Corliss engine drive for the operation of both the fresh-air supply and exhaust fans.

The ventilation is applied to the building in general on the downward system, the fresh air being delivered to the rooms supplied near the ceiling line, while the foul air is exhausted through registers near the floor line. An exception to this is to be noted, however, in the case of the fresh air supply to the interior court areas which rise from the basement through the center of the building to large size double sky-lights at the roof line; in this case the hot blast is delivered to these spaces through registers located 10 ft. above the first floor level, the purpose being principally to deliver heated air centrally under the sky-lighting which will diffuse with the cool descending currents from the glass surface and prevent cold drafts. The mechanical ventilation is confined entirely to the basement and first and second stories and the greater part of it is applied to the more important offices on the first floor. On this latter floor, which has a clear head-room from floor to ceiling of 19 ft., the counting room of the Water Board, the Tax Commissioner's business office and the Tax Receiver's counting room are large important offices in which profuse ventilation was required. On the second floor there is the meeting room of the Board of Works, the Mayor's office and the meeting room of the Police Board, all large rooms, to be ventilated, while in the basement there are two police court rooms, the business office of the Street Department, and the general office of the Alms Department of the City, which are extensively occupied and require ample ventilation. Ventilation arrangements in the Common Council chamber was carefully designed to produce the best results without bringing the system into evidence and the design follows closely the methods which are usual in theater and public hall ventilating installations. In addition to this ventilation is provided in the sub-basement for both the engine room and a jail room of the Police Department.

The proportions of fresh air supply and exhaust selected for the various offices ventilated were taken with reference to average conditions of occupancy, while in the Common Council chambers, the court-rooms and the various meeting rooms, ample ventilation is provided for maximum conditions of occupancy, fully 30 cu. ft. per minute being supplied for every person accommodated in the room or hall. In addition to the capacity of ventilation provided in these rooms for crowded conditions, the distribution of both supply and exhaust registers were carefully arranged to produce most effective results in clearing the air in all parts of the room. The registers and duct work are designed throughout for low velocities of flow, those for fresh air supply being operated with delivery velocities of about 2,000 ft. per minute in the basement duct lines which is reduced in the rising flues and connections to about 1,000 ft., and through the delivery registers to about 500 ft. per minute. The ducts and connections of the exhaust ventilation system are similarly proportioned, except that slightly lower velocities of flow are provided for. The details of the duct system connections and outlet registers for both fresh air supply and exhaust ventilation from all rooms in the building are presented in an accompanying table from which the general proportions of the system may be observed.

The ventilating systems, both fresh air supply and exhaust, are operated by fans located in the sub-basement. Owing to the extent of the service, two blower units are used in either case instead of one large unit, and each two units are located in spacious fan rooms that serve as intake chambers, the delivery being made direct from the fan outlets to the duct work or tunnel connections as the case may be. The fans are all three-quarter-housed steel plate fans, built by the B. F. Sturtevant Co., and have 12 vane wheels, 8 ft. in diameter, which are 60 in. in width for the fresh air supply fans and 48 in. wide for the exhaust fans. They are all operated at 225 r.p.m., at which the supply fans have each a capacity of 62,250 cu. ft. per minute or a total capacity of 12,500 cu. ft. per minute for the fresh-air supply division, while the exhaust fans at this speed handle 50,000 cu. ft. per minute each, removing together 100,000 cu. ft. from the building per minute. A unique feature of the fan installation is the method of drive, which consists of a 100 h.-p. Corliss steam engine with belted jack shaft driving connections. This engine is, as stated in the preceding article, located in the westerly portion of the sub-basement from which it is belted to a 98-ft. jack shaft extending along the rear wall in the direction of the fan rooms. This shaft is operated at 150 r.p.m., and the fans are driven by single belt drives, the wheel shafts being coupled in tandem. The engine is a Watts-Campbell simple Corliss engine with 16x30-in. cylinder and operates normally at 75 r.p.m., at which speed it develops 75 h.-p. It has a 10-ft. fly-wheel which is belted direct to the jack shaft and is fitted with a safety governor which will automatically stop the engine should the speed be increased more than 10 per cent. above normal.

The fresh air supply fans are located in a fan room 22x44 ft. in size in the easterly rear corner of the sub-basement to which the fresh air is drawn in through a group of cheese-cloth air filters and a set of tempering coils; the room itself thence serves as an intake chamber, from which the fans draw directly while delivery is made through duct connections to the distributing duct lines outside. The air filter consists of a series of 8 cheese cloth frames, 7 ft. in width by 11 ft. high, which present a total area of filtering medium of about 600 sq. ft., with which, at the maximum delivery of the fresh air supply fans of 12,500 cu. ft. per minute, a low filtering velocity of about 20 ft. per minute is obtained. The screens consist of wooden frames upon which the cheese cloth medium is stretched over wire netting for stiffening and backing purposes and they are mounted in an angle iron frame work, with provisions for removing when necessary for cleaning.

The air supply is heated in winter weather before being delivered to the buiding by a tempering coil in the fan intake and reheater coils in the duct delivery connections to the various rooms, by means of which arrangement the temperature of the air delivered to the various rooms may be accurately controlled. The tempering heater consist of a row of 10 special cast-iron radiators each containing 150 sq. ft. of radiating surface which are mounted in a row on a 12-in. brick wall, 5 ft. in height between the fans and the air filter. The upper portion of the rooms surrounding the radiators is shut off by a galvanized iron partition while in the brick supporting wall are three 36x60-in. dampers for the purpose of by-passing the tempering coil when desired, thus reducing the temperature to which the air supply is tempered in the intake.

The reheating coils are installed in the fresh air supply ducts to each of the rooms ventilated, for individual heating of the air thus supplied according to the requirements of each room. They are installed in the sizes indicated in the accompanying table of duct sizes and each reheater is thermostatically controlled from the room served. With this arrangement the most effective application of the indirect heating is secured as each delivery is thus independently adjusted to the heating requirements and is shut off whenever the direct radiators in the room can maintain the desired temperature. The Johnson system of temperature regulation is installed, there being thermostats in each of the rooms ventilated which, in addition to that controlling the direct radiation, controls all of the indirect heating of that room. The tempering coil is under the control of a thermostat in the supply fan room to regulate the amount of tempering of the incoming air.

SIZES OF VENTILATING DUCTS AND APPARATUS.

Floor	Room.	Fresh Air Supply Systems. Size ft.	Ducts, ins.	Registers, ins.	Reheater sq. ft.	Exhaust Ventilating Systems. Ducts, in.	Registers, ins.
Sub-	Engine Room	36 x 57	......	......	......	1—10 x 24	1—30 x 24
Basement	Jail Room	40 x 40	1— 6 x 18	50 holes.			
(11-ft. ceiling.)				2 in. diam.	100	1—6 x 24	1—18 x 24
Basement	Court Room	24 x 46	1—8 x 78	1—24 x 78	330	1—12 x 24	2—18 x 24
(16-ft. ceiling.)	" "	24 x 46	1—8 x 78	1—24 x 78	330	1—12 x 24	2—18 x 24
	St. Dept. Business Office	26 x 65	1—8 x 24	1—24 x 24	370	2—8 x 24	2—24 x 30
			1—8 x 42	1—24 x 42			
	Alms. Dept. Gen. Office	27 x 28	1—8 x 36	1—24 x 36	190		
	Main Corridor		Space under dome.			4—6 x 66	4—18 x 66
First Floor	Water Bd. Count. Room		1—8 x 30	1—24 x 30	960	2—8 x 24	2—24 x 24
		26 x 100	3—8 x 42	3—24 x 42		2—8 x 30	2—24 x 30
(19-ft. ceiling.)	Tax Com. Business Office	36 x 42	2—8 x 42	2—24 x 42	460	1—8 x 30	1—24 x 30
	Commissioner's Office	14 x 31	1—8 x 24	1—24 x 24	130		
	Secretary's Office	17 x 22	1—8 x 24	1—24 x 24	110	1—8 x 24	1—24 x 24
	Clerk's Office		1—8 x 30	1—24 x 30			
		27 x 27	1—8 x 36	1—24 x 36	220	1—8 x 24	1—24 x 24
	Tax. Rec. Count. Room	35 x 60	3—8 x 42	3—24 x 42		2—8 x 24	2—24 x 24
					660	2—8 x 30	2—24 x 30
	Interior Court		4—24 x 36	4—36 x 60	3200		
Second Floor.	Meet. Room Bd. of Wks.	35 x 60	4—8 x 42	4—24 x 42	480	4—8 x 30	4—24 x 30
(17-ft. ceiling.)	Mayor's Gen. Office	24 x 32	2—8 x 8	2—16 x 16	200		
	Private Office	14 x 32	1—8 x 30	1—24 x 30	120	1—8 x 24	1—24 x 24
	Meet. Room Police. Bd.	24 x 35	1—8 x 36	1—24 x 36	230	1—8 x 30	1—24 x 30
Common Council Chamber		48 x 60	6—15 x 48	2—15 x 78	2160	1—15 x 36	2—27 x 84
				2—36 x 48		1—24 x 96	15 x 180 Grille
				2—30 x 50			

The exhaust ventilating fans are located in an 18x20-ft. room in the central portion of the sub-basement space into which the exhaust gathering ducts from all parts of the building are led, this room serving as an exhaust chamber for the fans. The gathering duct connections consist, as will be noticed from the sub-basement plan of the City Hall in the preceding article, of two 6x66-in. ducts, a 34x108-in. duct and a 42x72-in. duct. The fans have intake direct from this chamber and deliver to the atmosphere through the piping tunnel which extends underground to the boiler house building at the rear of the main building. This tunnel is, as stated in the preceding article, 8 ft. square, and connects at the boiler house end, into a large brick flue rising to a point about 40 ft. above the sidewalk, where it has a hooded outlet. This flue is 6x15-ft. in area and has a full sized damper near the top which is controlled from below by ropes to permit of shutting off the outlet in case it is desired to shut down the system in cold weather. The ventilating flues are all without automatic dampers or control with the exception of those from the Council chamber which have automatic dampers under the control of thermostats in the chamber which causes them to open when the temperature increases above a predetermined point and closed when the temperature lowers.

The public toilet rooms of the building are ventilated by independent exhaust systems in order to prevent the possibility of communication of odors through the duct work to other parts of the building. These toilets are located in the two rear corners of each floor from the basement to the fourth floor, there being two on each floor, about 11x17 ft. in size, or 10 in all, and for their ventilation, two 2½x5 ft. vent shafts were built in the wall construction adjoining these rooms, from the sub-basement to the roof in either corner. They are connected with the toilet rooms by 6x6-in. vent register openings at the ceiling line for exhaust and also serve an important purpose in accommodating the soil pipes and other pipe lines of the plumbing system in open construction. These vent shafts are each connected in the attic to motor-driven cone exhaust fans, which operate continuously, independent of the other ventilation systems, and discharge through copper vent hoods through the roof. The fans are 36-in. 16-blade full-cone cased fans which are direct-connected to 3 h.-p. Sprague motors and operate at 650 r.p.m. Owing to the use of alternating current for operation of the lighting service in the building, these motors are operated on an independent supply of 500-volt direct-current, for which a special service connection is made by the local lighting company, and suitable switches are installed for control of the motors from the sub-basement. The private toilet rooms in other parts of the building have outside windows and are not fitted for mechanical ventilation.

The mechanical plant of the City Hall was designed for the architects by James M. Seymour, Jr., consulting engineer, Newark, N. J. The architects of the building were John H. and Wilson C. Ely, of Newark, N. J., and Mowbray & Uffinger, New York. The commissioners for the new City Hall were Andrew Kirkpatrick, Gottfried Krueger and James E. Howell.

THE ELECTRIC PUMPING PLANT of the Scunthorpe, England, water works consists of two units which force a supply through 2 miles of 9-in. main against a maximum head of 240 ft. The supply is drawn from an infiltration gallery. One pumping unit consists of a horizontal triplex pump, belt-driven from a 50-h.p. alternating current motor. The second unit consists of a three-stage Worthington turbine pump, driven by a similar motor through a flexible coupling. Three-phase 25-cycle, 2,200-volt current is supplied from a station 4¾ miles distant through an underground transmission line. The inaccessibility of the pumping station for carting fuel and supplies made the adoption of electrical power essential. The use of gas, oil and steam was fully considered, but the peculiar nature of the undertaking was decidedly in favor of electricity.

Some Notes on Oriental Water-Works.

A paper read before the American Water-Works Association by George A. Johnson, principal assistant engineer with Hering & Fuller, New York.

During the writer's recent trip around the world it was his privilege to make a somewhat extended study of numerous Oriental water-works. It would be out of place in a paper of this character to go much into detail or to attempt a complete description of all the works visited. In this article, therefore, will be given as briefly as possible the more salient features of Japanese water-works, and of the works at Shanghai, China, Singapore, Straits Settlements and Bethmangala and Calcutta, India, observing the general lines followed by the writer in his illustrated lecture on this subject delivered last June at the Toronto Convention of this Association.

Some of the data used in this paper have been taken from an article by the writer which appeared in The Engineering Record, May 11, 1907. For their great kindness in aiding the writer in his endeavor to obtain information upon the works described, hearty acknowledgments are due to Dr. Y. Nakajima of Tokyo; Mr. S. Inoue and Dr. S. Tanabe of Kyoto; Mr. Z. Mita of Yokohama; Mr. K. Funabiki; Mr. H. Ono, Mr. K. Inouye and Mr. Y. Tsujimura of Osaka, Japan; Mr. McLeod and Mr. Mollison of Shanghai, China; Mr. Pierce of Singapore and Mr. Bell of Penang, Straits Settlements;; Mr. Fogarth of Bethmanagala and Mr. McCabe and Mr. Peirce of Calcutta, India.

Water Works of Japan.—There have been public water supplies of a kind in Japan since the year 1600 when Iyeyasu, founder of the Tokugawa dynasty of Shoguns, inaugurated the first public water supply at Tokyo. These original works were remodelled and improved some 65 years later, and were improved and extended many times during the next two centuries. It was not until 1892, however, that the present modern and efficient works were put under construction, and it was 1898 before they were completed.

To Yokohama belongs the credit for having installed the first modern system of water works in Japan, begun in 1885. For the data from which the following digest of modern water works practice in Japan has been prepared the writer is indebted to his friend, Mr. S. Inoue, Chief Engineer of Kyoto Municipality, Japan, and a member of this Association. In 1889 the construction of the Nagasaki water works was begun. Osaka commenced her works in 1892, Hiroshima in 1896, Kobe in 1897, Hakodate in 1898, Shimonoseki and Okayama in 1900 and Akita in 1903. In all, therefore, there are ten cities in Japan provided with public water supplies, nine of which are filtered before delivery to the consumers, the Hakodate supply being unfiltered. In addition to these ten cities there are Kamiura, Sawarazawa and Iizuka, towns with populations of 2,165, 1,396 and 1,240, respectively, which have public supplies, that of one, Kamiura, being filtered.

The total population of the thirteen cities and towns which have public water supplies is in round numbers about 4,100,000, and of this number roughly 4,000,000 are supplied with filtered water. In general terms about one-third of all service lines are metered, and there is a fire hydrant provided to about every 50 houses. The average daily water consumption is about 25 gallons per capita. The total capital cost of all existing Japanese waterworks systems to date is in round numbers $11,500,000, or $2.80 per capita.

Tokyo Water Works.—The original design of these works called for a capacity of 45,000,000 gal. per day, or sufficient to serve a population of 1,500,000. Construction work was begun in 1892 and the works were first put into commission in 1898. In 1904 the population of Tokyo was 1,870,628.

The intake is located on the Tama River at Hamura, and from there to the present works the water flows by gravity through about 30 miles of open and closed canal. On reaching the works at Yodobashi the water passes through sedimentation basins, three in number, each 720 x 360 x 19.5 ft. deep, having a total capacity of 67,300,000 gal. These basins may be worked intermittently or continuously and when operating as continuous flow basins the period of sedimentation is equal to about 36 hours, and the velocity of flow through them to about 0.067 in. per second.

From the sedimentation reservoirs the clarified water flows through regulated outlets onto slow sand filters, of which there are eighteen one acre units. The sand layers are 30 in. in depth and are supported by 24-in. of graded underdraining material. The filters are operated at a rate of 2,933,000 gal. per acre daily, corresponding to a total gross capacity for the 18 filters of 52,794,000 gal. daily.

The filters require scraping about seven times a year on an average. At such times the dirty sand is removed from the beds, dumped into cement lined troughs, water applied and the sand agitated by coolies with rakes until clean.

There are three filtered water basins, all covered, located at Yodobashi, Hongo and Shiba respectively. The capacity of each basin is 7,500,000 gal., corrresponding to a total storage capacity of about 12 hours.

Two thirds of the supply is delivered by gravity to the low level districts. The remaining one-third is pumped at the Yodobashi station to the high level district in Yotsuya, Akasaka, Azabu, Shiba, Kojima, Ushigome, Koishikawa, Hongo and Kanda wards. The pumping station at Yodobashi contains four 300-h. p. pumping units each of a capacity of 7,500,000 gal. per day when working against a head of from 80 to 100 ft. There are twelve Lancashire boilers and two sets of Green economizers.

The charges for water vary, according to the use to which it is put, from 6 to 10 cents per 1,000 gal. The water is of excellent quality, clear, soft and without noticeable color.

At the present time there are 85,539 services and 5,177 fire hydrants. The metered services number 20,514.

The water consumption ranges from 11 to 23 and averages 17 gal. per capita daily. The total cost of works to date is $4,250,000.

Osaka Water Works.—The Osaka water works were put under construction in 1892, and originally designed to serve a population of 600,000. They were later extended to serve a population of 800,000. The population of Osaka in 1904 was 1,026,767.

The supply is derived from the Yodo River frrom whence it is raised by three centrifugal pumps to a series of four settling basins against a total head of about 30 ft. After 36 hours sedimentation the water is applied to slow sand filters and then pumped by seven triple expansion pumping engines of the Worthington type to the distributing reservoir at Osaka Castle against a total head of about 130 ft. The capacity of this storage reservoir is 3,750,000 gal.

The raw river water has a turbidity ranging from 10 to 350 parts per million. There will be about 20 days in the average year when the turbidity of the raw water will be over 100 parts per million, and about 50 days when it will be over 50 parts. The alkaliniity averages about 20 parts per million, and the numbers of bacteria range from 40 to 30,000 and average about 2,000 per cubic centimeter.

The settling reservoirs, four in number, are each 330 x 360 x 12 ft, effective depth. Their combined effective capacity is 42,600,000 gal. The sediment in these basins is flushed out once annually, when between 3 and 4 in., or about 5,200 cu. yd. are removed. The cost of labor for flushing out this material is 2 cents per cubic yard.

The cost of the basin completed in 1903, the effective capacity of which is about 10,000,000 gal., was $83,370, exclusive of the cost of land which costs at present $2.00 per tsubo, or $2,420 per acre.

The filters are of the slow sand type, eleven in number, ten of which are 151 x 182 ft. and one 182 x 350 ft. The total filtering area is therefore 7.77 acres. The tanks are of concrete and brick and the filter finished in 1903, 182 x 7.5 ft. deep cost $40,700 or $27,840 per acre exlusive of the filtering material which cost about $3,000 per acre additional.

The filters are operated in an up to date manner, although the rate of filtration is not automatically controlled and fluctuates with the pumpage. The average actual rate of filtration is 2,900,000 gal. per acre daily. The net rate is equal to about 2,600,000 gal. per acre daily.

Each filter requires scraping about twice a month on an average, and at such times about one-third inch of material is removed. No attempt is made to recover by washing the sand thus removed and it is used for fill. A gang of coolies is kept busily engaged at the river bank practically all of the time screening sand which is hand dredged from the bed of the Yodo River opposite the water works, brought to the shore in boats and there sun dried and pan screened.

The water rates vary from 10 to 60 cents and average about 20 cents per 1,000 gal. The filtered water is of excellent quality, has an alkalinity of about 20 parts per million, and during the year 1905 contained the average number of 25 bacteria per cubic centimeter.

There are at present 48,513 services of which 9,369 are metered. There are 3,000 fire hydrants. The total cost of the system to date is $1,653,020.

Yokohoma Water-Works.—The Yokohama water works were put under construction about 22 years ago when the first pipe lines were laid from the Sagami River. The new intake is located on the Doshi River near the foot of Fujiyama, and from there to the site of the filteration works on Nogiyama, a distance of some 30 miles, the water flows by gravity.

The works were originally designed to serve a population of 70,000 and have since been extended to serve 300,000 people. In 1904 the population of Yokohama was 331,597.

The raw water of the Doshi River is normally clear and noticeably free from color and turbidity except at times following heavy rains. The alkalinity of the water is about 27 parts per million.

On reaching the filtration works the four supply mains discharge into two receiving wells of masonry construction and from them is distributed to slow sand filters. These wells are small and permit of comparatively no storage. Suitable regulating devices are provided to maintain a constant water level in the wells and on the filters.

The three slow sand filters built some 21 years ago have recently been supplemented by three more filters. The beds are arranged in two batteries, one of four and one of two filters. The former are each 120 x 70 ft., and the latter are each 120 x 80 ft., corresponding to a total filtering area of 1.212 acres. The tanks are built of masonry and brick. The sand layer is 2.5 ft. thick supported on a layer of graded underdraining material 18 inches in depth. The sand is of medium size, rather dark in color, and of good stable quality. It costs about $2.75 per cubic yard in the filters.

The filters are operated at the somewhat high rate of 6,530,000 gal. per acre daily, and require scraping about once a month. Sand washing procedures are similar to those employed at the Tokyo water works.

There are two baffled clear water basins, both covered and having a total capacity of 3,192,000 gal., corresponding to a storage of practically 12 hours supply.

The filtered water is high grade, clear, soft and colorless, and stands in enviable repute among the citizens of Yokohama. The works are well built and well operated. There are at present 2,745 metered and 7,679 unmetered services. There are 1,236 fire hydrants, or one to every 50 houses. The consumption ranges from 19 to 29 and averages 24 gal. per capita daily. The total cost of the system to date is $1,548,140.

Kobe Water Works.—The Kobe water works were put under construction in 1897 and consist of impounding reservoirs in the hills immediately back of the city, slow sand filters and small distributing reservoirs. The system is a gravity one throughout.

The impounding reservoirs, two in number, have a total capacity of 483,000,000 gal. corresponding to a storage of 140 days supply at the average rate of consumption of 3,480,000 gal. daily. The catchment area for the most part consists of the steep slopes of the hills back of the city and two small brooks serve as the main feeders. The watershed is but sparsely populated owing to its mountainous character.

The raw water, owing to the lengthy period of storage allowed, is never excessively muddy when applied to the filters. It is soft and free from noticeable amounts of color.

The filters are eleven in number, and have a total area of 3.04 acres. Prior to its application to the filters the water passes through a small settling reservoir of a capacity of 1,000,000 gal. The distributing basins are 5 in number and have a total capacity of 260,000 gal.

There are at the present time 11,581 services in the city, 2,576 of which are metered. There are 1,173 fire hydrants. The works were designed to serve a population of 250,000. In 1904 the population of Kobe was 295,276.

The water consumption ranges from 20 to 40 and averages 30 gal. per capita daily. The total cost of the system to date is $1,468,640.

Nagasaki Water Works.—These works were put under construction in 1889, and consist of impounding reservoirs, slow sand filters and distributing reservoirs. It is a gravity system throughout.

The original works were designed to serve a population of 60,000, but have since been extended to serve 182,000. In 1904 the population of Nagasaki was 159,041.

The impounding reservoirs are three in number and have a total storage capacity at a daily average consumption of 1,680,000 gal. or 293 days supply, or 493,000,000 gal. The supply is drawn frrom small mountain streams.

From the storage reservoirs the water flows to the slow sand filters, nine in number and having a total area of 2.36 acres. From the filters the water flows to four clear water basins, having a total capacity of 2,930,000 gal., from which it is distributed by gravity to the city.

At the present time there are 5,901 services in the city, 953 of which are metered. There are 492 fire hydrants.

The total cost of the system to date is $788,080.

Hiroshima Works.—Construction work was begun in 1896. Population in 1904 was 127,117. The works were designed to serve a population of 120,000. The source of water supply is the Ota River. There are two settling basins with a total capacity of 1,200,000 gal. The slow sand filters four in number, have a total area of 1.75 acres. The clear water basins, two in number, have a total capacity of 950,000 gal. Water consumption ranges from 15 to 40 and averages 28 gal. per capaita. There are at present 6693 services in the city, 1610 of which are metered. There are 709 fire hydrants. The total cost of the system to date is $465,560.

Shimonoseki Works.—Construction work was begun in 1900. Population in 1904 was 46,905. The works were designed to serve a population of 60,000. The supply is derived from small mountain streams. The impounding reservoir has a capacity of 286,000,000 gal. There are three slow sand filters with a total area of 0.87 acre. There are two clear water basins with a total capacity of 270,000 gal. Distribution is by gravity. Total cost of the works to date is $449,080.

Okayama Works.—Construction work was begun in 1900. Population in 1904 was 81,324. The works were designed to serve a population of 80,000. The source of supply is the Asahi River. There are two settling basins with a total capacity of 3,090,000 gal. There are four slow sand filters, with a total area of 1.31 acres. There are two clear water basins with a total capacity of 810,000 gal. The total cost of the syystem to date is $401,900.

Akita Works.—Construction work was begun in 1903. The population in 1904 was 33,695. The works were designed to serve a population of 40,000. The source of supply is drawn from the Asahi River, a branch of the Omono River The settling basin has a capacity of 100,000 gal. There are two slow sand filters with a total area of 0.66 acre. The capacity of the clear water basin is 750,000 gal. The total cost of the system to date is $235,150.

Hakodate Works.—Construction work was begnu in 1898. Population in 1904 was 88,071. The works were originally designed to serve a population of 60,000, but have since been extended to serve a population of 150,000. The supply is drawn from Aka River. The storage reservoir has a capacity of 1,530,000 gal. The water is not filtered. There are two distributing reservoirs the total capacity of which is 1,920,000 gal. The daily water consumption ranges from 22 to 35 and averages 26 gal. per capita. There are at present 2,509 services in the city, 729 of which are metered. There are 410 fire hydrants. The total cost of the works to date is $229,310.

Sawarazawa Works.—Construction work was begun in 1898. Population in 1904, was 1,396. The works were designed to serve a population of 1,229. The supply is drawn from small mountain streams. The impounding reservoir has a capacity of 300,000 gal. The water is distributed by gravity direct from this reservoirs to the consumers. The total cost of the works to date is $5,060.

Iizuka Works.—Construction work was begun in 1898. Population in 1904 was 1,240. The works were designed to serve a population of 1,085. The supply is drawn from mountain streams. The impounding reservoir, from which the water is distributed direct by gravity to the consumers, has a capacity of 200,000 gal. The total cost of the works to date is $4,090.

Kamiura Works.—Construction work was begun in 1900. Population in 1904 was 2,165. The works were designed to serve a population of 2,500. The source of water supply is the Ushimaki River. The water is applied direct to a small sand filter (area .017 acre). The clear water basin has a capacity of 22,000 gal. The total cost of the works to date is $3,410.

Water Works of Shanghai.—Shanghai is located on the east coast of China, south of the Yellow Sea and near the mouth of the Yang-tse-Kiang. It has a population of about 600,000. The water works were built with the particular object in view of supplying the foreign population of that city with pure water. The total number of people tributary to these works at present is in round numbers 45,000, of which 12,000 are of English and American birth and the remainder Chinese.

The water supply is drawn from the Hwang-ho River, the waters of which are normally very turbid, as is the case with all rivers emptying into the Yellow Sea. In fact it is the excessive muddiness of such waters as those of the Yang-tse-Kiang and Hwang-ho that gives the name to the Yellow Sea, the waters of which are colored a deep yellow for more than a hundred miles from the mainland of China.

The raw water is raised from the river by two centrifugal pumps of local make and discharged through two 20-inch pipes into the settling basins. These basins are four in number and provide a period of sedimentation of about 25 hours.

From the settling basins the water is applied to slow sand filters of which there are twelve. The areas of these beds range from ⅙ to ⅓ acre. Considerable fine clay remains in suspension even after a preliminary sedimentation of 25 hours, and the filters require scraping at intervals of one month or less.

Passing the filters the water flows to a clear water reservoir having a capacity of 6,000,000 gal., and is pumped therefrom through one 25-in. and two 20-in. mains to the consumers. The daily pumpage ranges from 5,000,000 to 7,000,000 gal.

The construction work in this plant is high grade, and the filters are very efficient notwithstanding the fact that they are somewhat overworked at times.

Singapore Water Works.—Singapore is located on the Island of Singapore at the southern extremity of the Malay Peninsula. The island is about 250 square miles in extent and is separated from the mainland by the narrow Straits of Tebrau. The population of the city is estimated at 200,000.

The water supply is derived from small jungle streams which drain about 28 square miles. The storage reservoir is located on Thomson Road a short distance outside the city and has a capacity of about 1,000,000,000 gal. The raw water is not particularly turbid, but is always highly colored. Much of the time the water has a strong fishy odor and to the taste is often highly objectionable.

The raw water flows from the storage reservoir by gravity to the outskirts of the city where the filtration works are located. The filters are of the slow sand type, eight in number, with a total filtering area of 2 acres. Operation is intermittent; that is, the beds are allowed to rest empty about 12 hours in every one to two weeks, the length of the operating period varying according to the season. By this procedure it is understood that a considerable degree of success has been achieved in removing the objectionable tastes and odors from the water, although at the time of the writer's visit, July, 1905, the filtered water had a pronounced "fishy" odor. The actual rate of filtration is said to be about 1,050,000 gal. per acre in 24 hours, corresponding to a daily yield of about 2,100,000 gal. for the eight filters. The average daily consumption is said to be about 5,000,000 gal. daily.

Water Works at Bethmangala, India.—These works were constructed in 1903-4 for the purpose of supplying the Kolar Gold Fields with pure water. The gold fields are located in the State of Mysore, in southern India, and about 60 miles from Bangalore. The water works are located just outside the village of Bethmangala and about 7 miles from the gold fields. Up to the time of installing the present works the water supplied to the laborers at the mines was not only of extremely poor quality, but very scarce, a small given amount being allowed each laborer daily. These laborers are chiefly natives, but there are also, it is understood, some 800 English miners among the 20,000 workers at the mines.

The water supply is derived from the Palar River upon which the large storage reservoir at Bethmangala, together with many similar reservoirs used chiefly for irrigation purposes, is located. The capacity of this reservoir is 1,737,612,000 gal., sufficient at a daily consumption of 2,400,000 gal. for 724 days supply. The rainfall at Bethmangala averages only about 17 in. annually and the raw water is deeply colored, and at times high in suspended matter. (A number of the details which follow have been taken from an article by the designer of these works, M E. B. Weston, and published in The Engine ing Record, Dec. 17, 1904, acknowledgment which is hereby made.)

As to the filtration and distributing syster the raw water enters a masonry inlet chamber ated in the Bethmangala reservoir and thence f s by gravity to a suction well adjacent to t filter building from which it is raised by lift pumps to the coagulating basin. The gulant (sulphate of alumina) feed enters the wa- ter pipe leading from the low lift pum o the coagulating basin. After four hours c nuous coagulation and subsidence the wate passes over outlet weirs into the supply p lead- ing to filters of the American type. P ng the filters it is discharged through West auto- matic controllers into a flume and the into the clear water basin, being raised thence high lift pumps through a 16-in. main to th Kolar gold field against a total head of abou o ft.

The coagulating basin, located just out the filter building, is uncovered, is constru of granite masonry and lined inside with br laid in "surki" mortar. The floor of the basin is con- crete. The basin is divided into two ons by a partition wall and has a capacity o out 400,000 gal.

The filters, four in number, are of the ell gravity type, circular in plan and built o an- ite masonry. Over the manifold collecti ys- tem is placed a thin layer of gravel surn ed by 3.5 ft. of fine sand. Each filter has ed capacity of 620,000 gal., corresponding to tal capacity for the four filters of 2,480,000 per 24 hours. The rate of filtration is auto ally controlled by means of Weston effluent oll- ers.

The clear water basin is located ab o ft. from the filter building, is below gro evel and covered. The basin is built of gra ma- sonry and the roof of masonry.

There are two low lift pumping out ith a total capacity of 5,280,000 gal. per 2 irs, and three high lift outfits of the Wo ton type of a total capacity of 3,600,000 ga 24 hours. There is also a centrifugal p for washing the filters having a capacity 000 gal. per minute. The last named is be en by a Pelton wheel operated with water the 16-in. high pressure main. Steam to he high and low lift pumps is supplied wo Babcock & Wilcox boilers, each of 225 h th Green economizers.

There is a stand tank at Champio fs Mine in the gold fields, built of brick n cement mortar. All the filtered water is d to this tank from which lead branch lines to similar tanks located at the different mines, and to the service reservoir at Robertsonpet, a town about a mile distant.

The works were designed by Mr. Edmund B. Weston and built by the Jewell Export Filter Co., for whom Mr. R. W. Lawton acted as superintendent of construction. The amount of money appropriated for this work was $324,000.

Since the works were completed periodic analyses of the raw water and filtered water have been made by the official bacteriologist of the Mysore Government. The average results of the test made during the period Sept. 8-11, 1906, the last results available to the writer at this time, showed 4,350 bacteria per cubic centimeter in the raw water and 13 in the filtered water. Cholera, which prior to the installation of these works was very prevalent, has been practially absent among the employees of the mines since the works were put into operation. The filter plant itself is a model of neatness, and is operated in the most intelligent, painstaking and efficient manner.

Calcutta Water Works.—Calcutta is located in the province of Bengal, on the right bank of the Hugli River and about 45 miles inland from the Bay of Bengal. The present population is estimated at 1,100,000.

The Hugli River, from which Calcutta derives its water supply, is the most western branch of the Ganges. The drainage area of the Hugli is about 25,000 square miles, although in addition to the run-off of this watershed considerable excess flow from the Ganges enters the Hugli during July, August and September, when the flood season is at its height, through the Bhagirathi, Jellinghi and Matabanga Rivers which connect the Ganges and the Hugli above Palta.

The waters of the Hugli River are normally very muddy, and at times, especially in the rainy season, excessively so. A better idea of the effect on the muddiness of the water produced by the heavy rains which occur in the rainy season may be had from the statement that while the average rainfall in this vicinity amounts to only about 60 in. annually, as much as 40 in. has fallen in a single week, and in 1900 the rainfall on two successive days was 14.5 and 10.8 in.

The river water at the intake at Palta is subject to tidal influences; in fact the rise of the tides is felt 75 miles above this point. During the dry season, namely, February to June, the water is quite brackish for a part of practially every day, necessitating a cessation in pumping for substantially one-half of the time.

The original works were put under construction in 1867, greatly enlarged in 1888, and now consist of two pumping stations where the water is raised from the river, settling reservoirs, slow sand filters, and gravity conduits to a reservoir on the outskirts of the city. Auxiliary pumps here force the water through mains direct to the consumers in the northern part of the city, the remainder being discharged into three reservoirs, two situated in the town and one in the suburbs, from each of which it is pumped to the remainder of the consumers.

The original settling basins, construction of which was begun in 1867, are six in number, and are built of masonry. Four are provided with semi-concentric silt-catching pits and two are plain. The original basins are each 500x250 ft., and range in depth from 7 to 9 ft. The total capacity of these six basins is 21,000,000 gal.

The "new" settling basins, finished about 15 years ago, are merely earth excavations, puddling being practically dispensed with. Notwithstanding the fact that these basins are excavated in a sandy clay the leakage amounts to practically nothing. Two of these basins are each 2,500 x 350 x 9 ft. deep. The remaining two basins are each 2,500 x 250 x 9 ft. deep. The total capacity of the four basins is therefore 84,000,000 gal., making a total capacity for the six original and four new basins of 105,000,000 gal. These basins are worked on the fill and draw plan and the period of sedimentation is therefore variable.

As the water enters the settling basins it is treated for approximately three months in the year, namely, during the rainy season of July, August and September, with aluminoferric. The chemical is applied in the proportion of about 2 grains per gallon, although the method of application precludes accurate measurement. A bag of chemical is suspended directly over the inlet, and is dissolved by the inflowing water. The aluminoferric costs about $20.50 per ton delivered at the works.

The original filters are twelve in number, each 100 x 200 ft., corresponding to a total filtering area of about 5.51 acres. The filtering material consists of 30 in. of fine river sand supported on 4 in. of course sand and 12 in. of graded gravel, respectively. The effluent collectors consist of small cross drains covered with tiles. These drains lead the effluent to main collectors laid along the center of the beds and these main drains deliver the effluent into collecting wells from which it flows directly into the conduits leading to the auxiliary pumping station on the outskirts of the city.

The new filters are twenty-four in number, each 200 x 100 ft., corresponding to a total area of 11.02 acres. In construction these filters are in general the same as in the case of the original filters, with the exception that the effluent collectors consist of two courses of dry bricks laid sufficiently far apart to provide suitable waterways. The total filtering area of the thirty-six filters is 16.53 acres.

The average daily wastes consumption is estimated at 27,000,000 gal. daily (25 gal. per capita) and the actual rate of filtration at about 2,825,000 gal. per acre in 24 hours.

There are three effluent collecting wells in the plant, with a total capacity of about 42,000 gal., and from these wells the filtered water flows through two conduits to the outskirts of the city. The conduits are 4 and 3.5 ft. in diameter, respectively, and 12.5 miles long.

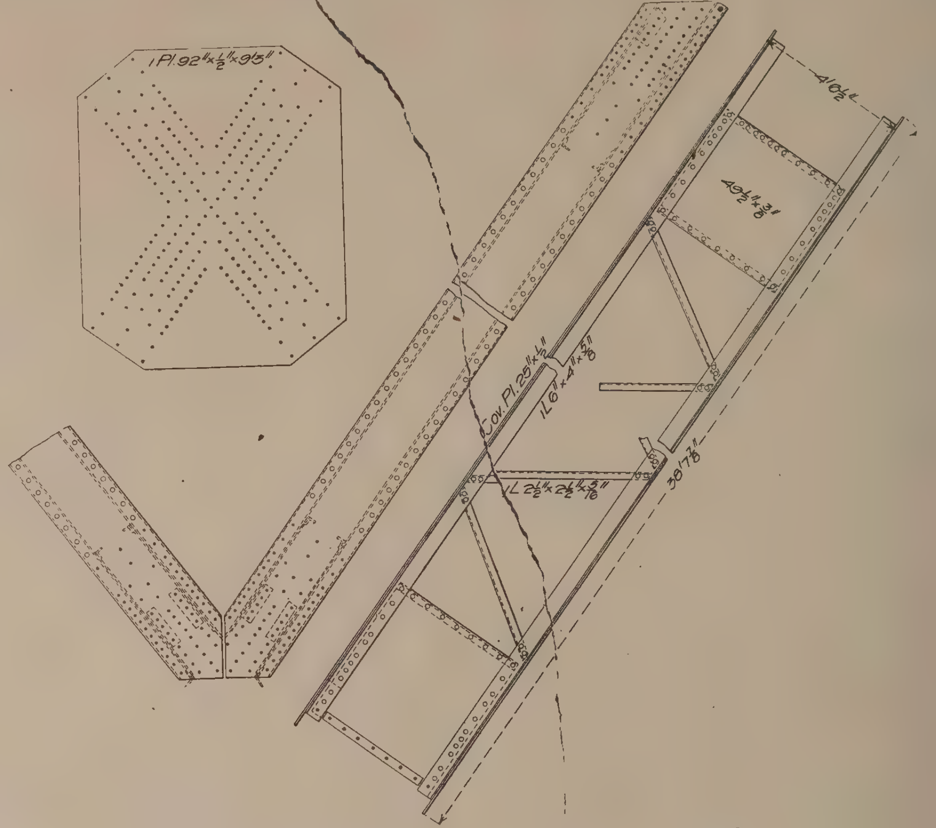
It is the custom at present to supply filtered water, to the entire city, under about 30 pounds pressure at the various distributing stations during the day hours, excepting the hours 10 a. m. to 3 p. m. during which hours water is supplied under low pressure only to the more thickly populated sections of the city.

Filtered water is not used for street sprinkling, sewer flushing or fire extinguishing purposes, a complete separate unfiltered water syster, being in use for this purpose, the water being pumped direct from the river into the raw water mains.

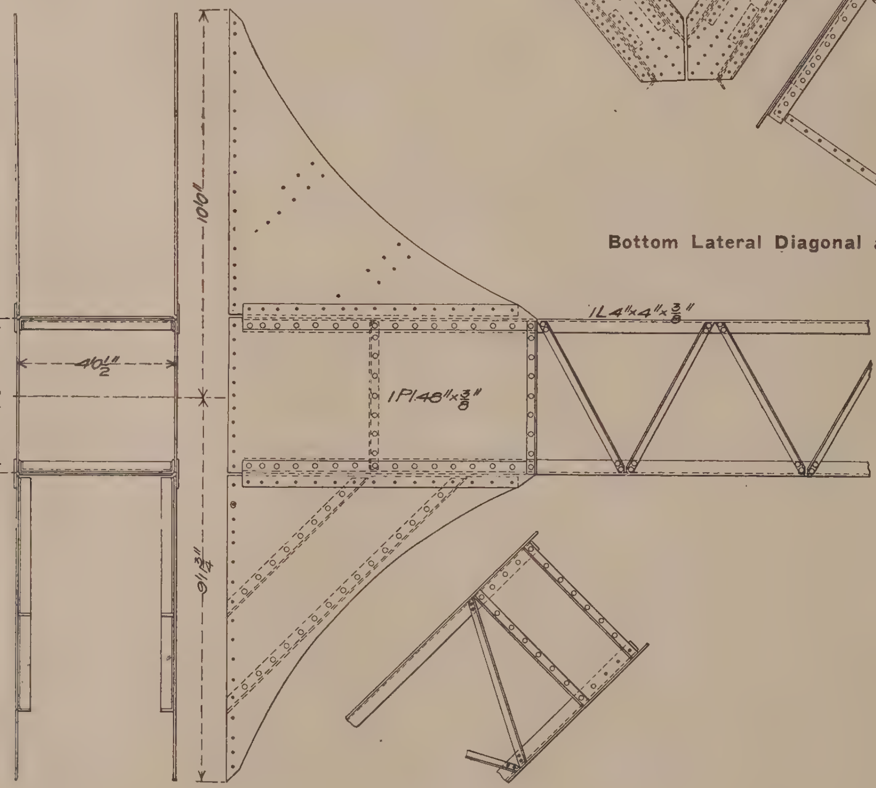
Tunnel Linings in Rock far below the surface are often considered exposed to extremely heavy pressures, which do not come into play immediately on excavation. According to Dr. Karl Brandau, such evidences of general pressure were never experienced during the construction of the Simplon tunnel. Where the superincumbent mass was greatest, the lightest type masonry lining was almost universally emplo and has never shown the least sign of da Wherever merely local and unimportant sures were observed, they were invariabl to decomposed rock of small internal co He therefore believed that no considera culties arise from the pressure of th posed rock in the construction of a at depths of more than 6,800 ft., in stone, though great difficulties are in plastic material of considera

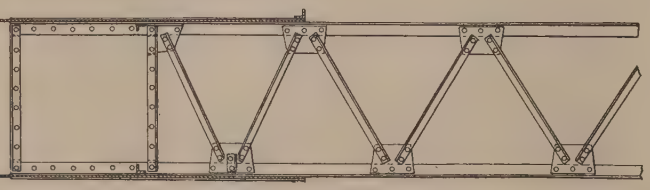
The Quebec Bridge Superstructure Details.—Part IX.

Transverse Bracing.—It is assumed that the bridge is exposed to a horizontal wind pressure of 25 lb. per sq. ft. on double the exposed surface of one truss and on one side elevation of the floor, one-half of the amount being static and the other half a live load. To provide for the stresses thus developed there are three lateral systems in the floor plane and in the planes of the top and bottom chords respectively, besides transverse bracing in the planes of all vertical posts. Horizontal shear is transmitted through special connections from the center suspended span to the ends of the cantilever arms and thence to the center posts where it is transmitted through the main transverse bent to the river pier. Wind stresses in the anchor arm spans are transmitted to the river piers and to the anchorage piers, reaching the latter directly from the floor system and the bottom chord and indirectly through the inclined end post and the vertical portal bents from the top chord system. The transmission of these stresses from the superstructure to the anchorage pier is effected by the very novel and ingenious connection illustrated in The Engineering Record of December 29, 1906.



Bottom Lateral Diagonal and Connection of Intersection.




Intermediate Transverse Strut.

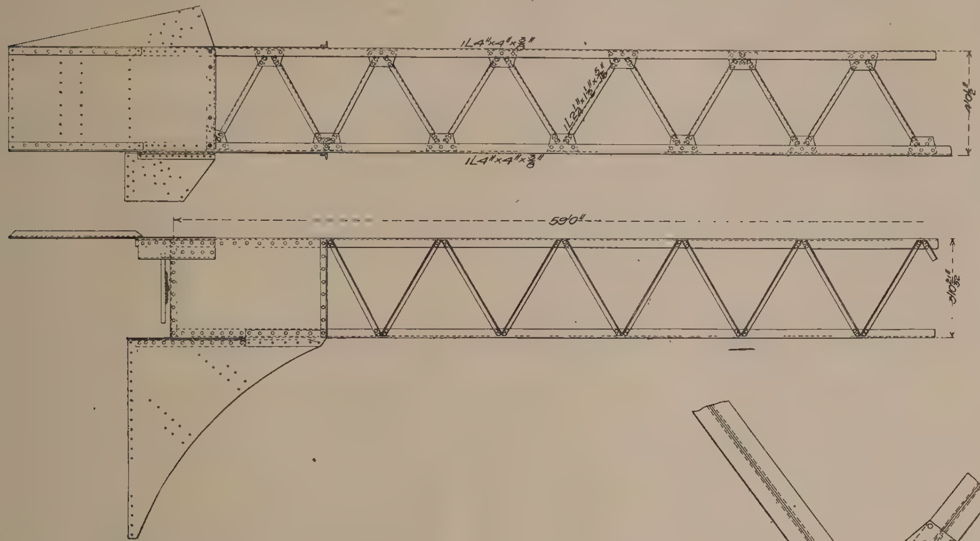
The top chords are connected by transverse struts at panel points and between them there are X-braces with I-shaped cross section having a n depth of 3 ft., and all of them made with rs of 6x3½x7-16-in. angles riveted to- k to back and latticed. One of the ade continuous and the other is cut he intersection where they are spliced top and bottom flange cover plates b-connection angles. The lattice bars are made with zig-zag angles having at each end two rivets in small gusset plates riveted between the vertical legs of flange angles. Their top and bottom flanges are field riveted between end connection plates at the ends of the transverse struts.

The top lateral transverse struts, like the diagonal members, are uniform throughout the anchor spans and have rectangular cross sections about 4 ft. deep and 4 ft. wide made with four 4x4x3/8-in. angles with their flanges turned inward and latticed on all sides by zig-zag 2¼x1½x5-16-in. angles with two rivets through the ends of each. Horizontal top flange plates project beyond each end of the struts and are field riveted to the top of the vertical post. The bottom flanges of the struts are also connected to the vertical posts at both ends by pairs of 3/8-in. gusset plate knee-braces 7½ ft. long which also serve as jaws to receive the field riveted connections of the X-brace diagonals. Horizontal and vertical batten plates are riveted to the four angles at both ends of the truss making a complete closed rectangular section there and stiffening it for the web plate connections with the diagonal struts.

The bottom lateral system consists of transverse struts at panel points and intermediate X-bracing with diagonal struts having rectangular cross section 4½ ft. deep and 25 in. wide, made with four 6x4-in. flange angles riveted to 25x½-in. top and bottom cover plates and united by vertical latticing of 2x3-in. zig-zag angle bars. Both struts are cut to clear with mitred joints at the intersection where they are spliced by field riveted 92x½-in. flange cover plates 9 ft. 3 in. long and by vertical web connection angles on the side plates. The ends of the struts are field riveted between horizontal connection plates projecting from the lower chord flanges. The lower chord transverse struts are similar to the X-bracing.

All vertical posts are connected by top and bottom and intermediate transverse struts, the panels between which, excepting that which includes the space immediately above the railroad track, are X-braced with diagonal struts having rectangular cross sections made with four angles latticed like those of the transverse struts. At intersections they are cut to clear and spliced like the lower lateral diagonals and at the ends their flanges are field riveted between wide gusset plates on the ends of the transverse struts. At the end of the anchor arm the roadway is at the same level as the lower chord and has room for no transverse bracing below it. As the depth of the truss increases there are either one or two panels of transverse bracing below the roadway and the diagonal members have I-shaped cross sections made with angles back to back latticed. The transverse struts above the roadway have very deep end cover plates field riveted to the flanges of the vertical posts with their edges curved to give a more pleasing outline. The projections of the plates below the horizontal struts serve as knee-braces and are stiffened by angle bracing frames like short trusses riveted between the inner faces of the plates and forming diagonals between the struts and the posts. In the deepest portions of the trusses special diagonals are provided in the panels just below the floor and their members virtually form portions of the trussed floor beams, as described in the last issue of The Engineering Record.

Mr. E. A. Hoare is the chief engineer of the structure and Mr. Theodore Cooper is consulting engineer. The contractor for the fabrication and erection of the steel work is the Phœnix Bridge Co.



Upper Transverse Strut, Quebec Bridge.

Heavy Excavation in Red Granite has been carried on along the line of the Grand Trunk Pacific Ry. at a cost of 19.4 cents per cubic yard for drilling and blasting, by methods recently described in detail by M. G. P. McFarlane in the "Engineering and Mining Journal." In the smaller cuts, hand drills with 1-in. steel were used on holes to a depth of 30 ft. The holes were started with two hammers to the drill, and when down about 5 ft., the drill turner also took a hammer, for the rapid blows jumped the steel enough to bore a fairly round hole. Steam drills were generally used in the large cuts, a 3-in. machine drilling to 25 ft., and a 3¼ or 3½-in. machine to 30 and 35 ft. The cheaper grades of steel were used almost exclusively, as they were found to wear about as well as the high grade brands. Mr. McFarlane found it desirable to drill two holes 10 ft. on each side of the center line of the cuts and burdened not to exceed 15 ft. The advantage of this was that very little drilling was necessary to square up the bottom of the cut. Where the cut exceeded 30 ft., he found it best to take it out in two benches. After drilling, a chamber was formed at the bottom of the hole by springing with dynamite enough times to make a place to hold the blasting charge. The latter was figured at 60 lb. of black powder or 40 lb. of dynamite for each 100 cu. yd. of the shot. The advantage of machine drilling was evident in the springing necessary to make the chamber, for heavy springing causes the rock to shift at times and the larger holes drilled by machines permitted considerable shifting before the hole was finally closed off. The slips and floors caused by springing put a practicable limit to the size of the blast, which was reached with 30-ft. holes burdened 15 ft., and throwing out 400 to 800 tons of muck.

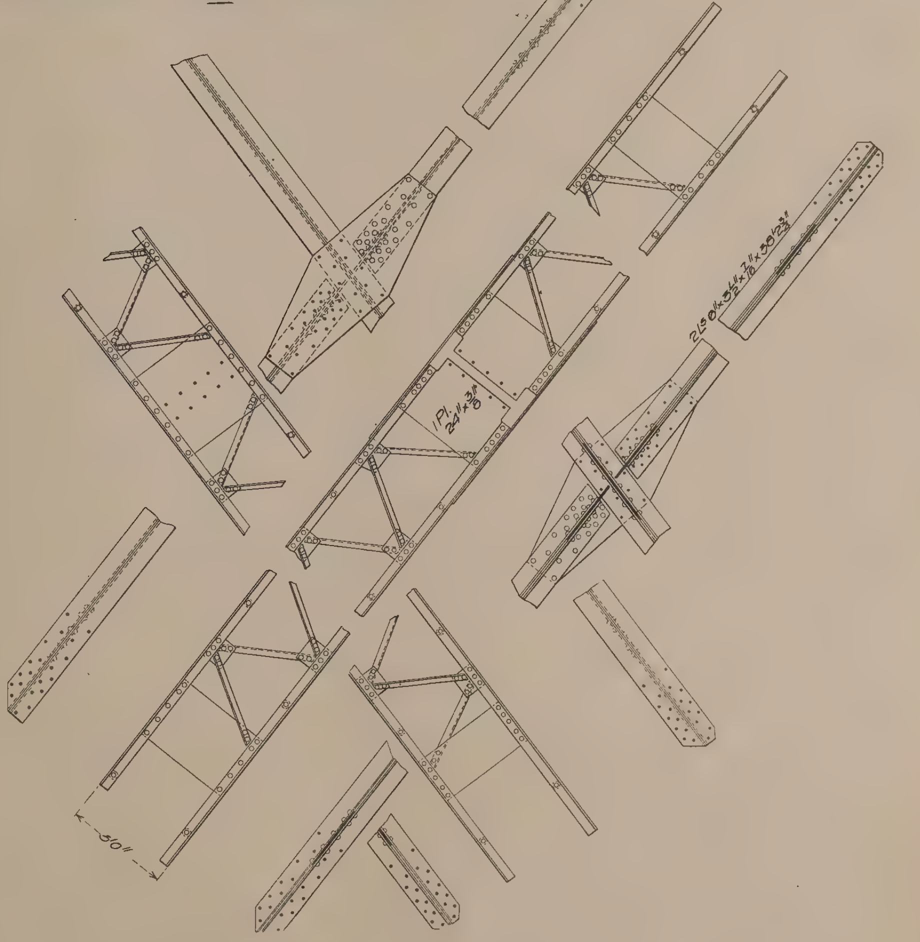
The Library System of Stone & Webster.

At the Asheville meeting of the American Library Association, a paper of unusual interest to engineers was read by Mr. G. W. Lee, on the library system of Stone & Webster, of Boston. This firm with its Engineering Corporation and their departmental offices, has the general control, including operation, engineering and financing, of some thirty public service corporations in various parts of the country, from Maine to Texas, from Puget Sound to Porto Rico, with also one in Cape Breton. Besides these, which have to do with gas and electric lighting, electric railway and power transmission, are three other industrial enterprises which would add electrochemical and textile manufacturing interests to the list. The library is at the service of them all, though particularly for the use of the headquarters in Boston.

Questions.—It is impracticable to give anything like a complete list of the questions and requests that come for immediate attention or for extended research, but a selection serves to indicate the scope of information which the library endeavors to have ready access to. The following are fair samples of what one would expect to find on the record of demands: (1) Underground conduit systems, more particularly the cost. (2) Periodical references on the grounding of the secondary. (3) Write-ups on power plants of Kansas City and Minneapolis. (4) Central station economies by Goldsborough and Fansler at the Niagara meeting of the A. I. E. E., July, 1903. (5) References on getting shocked through electric conductivity of fire streams. (6) The use of peat gas. (7) Vacuum system vs. direct steam heating. The answers to these particular questions were, for the most part, found through the indexes to the technical journals; though requests for works on railway construction, for methods of estimating population, for a book on boilers and stokers, and for information on the measurement of water flow were answered in other ways.

Questions of names and addresses frequently come up and, still more than the preceding, call for experience, besides familiarity with a number of reference books. They are such as might arise in almost any office, viz: (1) Name of Secretary of State of Texas. (2) Vice-President of Milwaukee, St. Paul & Sault Ste. Marie R. R. (3) Initials of Mr. Blackman, president of Rollins College. (4) How to spell the name of an automobile resembling "Michelon." (5) Is Charles S. Sperry's title "Captain Sperry?" Almanacs, newspaper directories, Who's Who, the advertising pages of trade journals, etc., are obviously possible sources of information for some of the above questions.

The group of questions concerning spelling, rhetoric, etc., like the one immediately preceding, includes the sort of questions people in general are likely to want answered, while savoring also of the personal use of the Library. The following are typical: (1) Is s always added for possessive singular after an apostrophe when a



Top Lateral Diagonals, Quebec Bridge.

word ends in s, i. e., is Davis' as correct as Davis's? (2) Authority for spelling to-day and to-morrow without a hyphen. (3) Authority for the spelling Phenix, Ala. (4) Is basket-ball one word or two words? (5) The abbreviation for mid-night. There has been many a failure to find rule or authority for much that one would expect to be settled by our ordinary dictionaries, encyclopedias or rhetorics. Particularly disappointing is it not to find cut-and-dried rules for addressing persons in public office.

Less obviously, to the uninitiated, the following list seems to bear upon the interests of street railway and lighting companies, viz: (1) Wealth of the United States and of the World. (2) Cost of living in Mass. for a number of years back, also an average for the whole United States. (3) Weights of different kinds of vegetables per bushel. (4) Altitudes of various cities. (5) Average temperatures of various U. S. cities. (6) Data on Key West. (7) Lumber shipments from Florida ports in 1904. (8) Is Savannah the greatest naval stores port in the world? It is such questions as these that stimulate one to preach a crusade for inter-library, inter-state, inter-national reference work, a clearing-house system for all human demands. But the people who ask these statistical questions are hardly interested in such Utopian ideas. They want their answers, and the frequency of such questions and the insistent demands to have them answered or to be put in the way of obtaining the answers, leaves Mr. Lee little time to work upon the construction of a royal road to anticipating all answers for all time to come.

Somewhat akin to the preceding are several of the following: (1) Discount on Cyclopedia of Applied Electricity for cash payment. (2) Standard works on financial matters, currency, banking systems, etc. (3) Should coal mine earnings be charged as railroad earnings where a railroad owns the mine? (4) Rates of interest of Interborough Railway notes. (5) Compound interest tables for annuity calculation. (6) The financial side of the Chicago traction situation. (7) Bank clearings for Seattle for 1905. (8) Assessed valuation of Seattle. (9) Comparative statements of the call and time money rates for the last six months of 1906, also the combined reserves of the clearing-house banks of Montreal. Finance is perhaps the common factor of business life, and a certain routine of reference books and experience enables one to put the questioner readily in touch with the answers to many questions of this kind, though one or two of the above proved to be puzzlers.

Again and again Mr. Lee has found that an apparently easy question has proved hopeless to answer. Look for the date of opening of the first interurban and see if you can readily find it. So also try to find in the ordinary rhetorics the proper way to address a woman's association: whether "Dear Madames," "Dear Mesdames," "Dear Sirs," "Ladies," or what not. In the actual case of this kind that came up the answer was obtained by telephoning the association in question and thus getting the answer from headquarters, "Dear Mesdames."

The inter-reference of office departments is of vital importance in the solution of many questions. The following were thus conjointly answered; and presumably the work of the Library in these instances was discharged in a few words, at a saving of much time: (1) Laws and ordinances governing Seattle elections (Ref. to Corporation Dept.). (2) Information on galvanizing (Ref. to Statistical Dept. and to Mass Institute of Technology). (3) Shall we buy the earlier volumes of transactions of Am. Institute of Mechanical Engrs.? (Ref. to Eng'g Dept.). (4) Capitalization of Turners Falls Pr. Co. (Ref. to Securities Dept.). (5) Cost of electric railway construction (Ref. to Statistical Dept.). (6) Trade catalogues or bulletins on file giving details of alternating current elevator equipment (Ref. to Purchasing Dept.). More questions are thus referred than the record shows, while of course the inter-working of all parts of the organization is something to be encouraged. Significant is the following extract from an address at a recent dinner of members of the office:

"One of the best known Americans to-day is our fellow-citizen of Boston, Edward Everett Hale. He has certain phrases that mean much, which he uses over and over again. They are the keynote of one of the most useful lives that has ever been lived. The principal phrases are, perhaps, 'Lend a hand' and 'Together.' In that way—together—an organization can accomplish more than in any other way, and we are here to-night to emphasize that word."

Libraries, clubs, societies, public depts., etc.

The following questions were answered, successfully or otherwise largely by an appeal to resources without the office sometimes merely by telephoning, sometimes by a visit to the public or other library, club, etc.: (1) Book on hydraulic accumulators (Books from Public Library). (2) Description of patent granted to W. N. Patten and others on leather machine about four years ago (Ref. found at Public Library). (3) Hermann's map of Oregon (Not found in office or in Public Library). (4) Growth of region near Philipsburg, Pa., through which Center and Clearfield Railway runs (Letters to local library and newspapers without satisfaction).

Kindred to the above are the following, some of whose sources of information are discussed later: (1) Concrete dwelling houses (This was in 1905, when a trade catalogue obtained of an agent seemed best source of information). (2) Latest specifications for structural steel of the American Association of Steel Manufacturers (Obtained Pocket Companion from Carnegie Steel Co.). (3) Resistance of steel wire (Information obtained by letter from manufacturers). (4) Cost of heavy machine tools (Advised to appeal to manufacturers or dealers). (5) Balanced draft system, referred to in the Electrical World of 12|23|05 as to be used by Hudson River Power Co. for Utica plant (Information obtained from the publisher by letter). (6) Practice in interurban bridge design for various live loads (Learned from publishers of Street Railway Journal that articles thereon were about to appear in their publication).

The following suggest particularly the problem of how to develop the Library: (1) Bauxite in Ga. and Ala. and areas of deposits. (2) How to dispose of 51 volumes of the Transactions of the American Society of Civil Engineers? (3) Effect of crowded English cities on public health. (4) Efficiency of transmission lines. (5) Resistances of alloys. In considering the above the following questions arise:

(1) How far shall we stock the Library with data on mineral resources? Out of our usual line, but likely to come up, are questions similar to the one regarding bauxite, as experience has shown.

(2) What shall we do with good things that take up room but are not in immediate demand? With the mass of literature that is out of date, superseded, dead, or otherwise supernumerary so far as our purposes are concerned? At present we have what we call a "give-away sale," which means that most of the material is thrown into the waste-basket. The particular question of disposing of the 51 volumes was personal, being asked by one of our engineers. Likely enough, in the near future we would gladly purchase them at a high price. Meantime supply and demand fail to meet.

(3) The question as to the effect of crowded cities characterizes the wide range of the work and the need for bearing in mind general articles that may have to do with the extension of trolley lines for increasing the suburban population. How shall we keep in touch with these broad ideas without spending on them more time than is justifiable? It is almost the same question as "What shall we read in the magazines?"

(4) The efficiency of transmission lines was a question soon dropped as not at the time likely to be answered. It suggests, however, the need for keeping alive to the literature of efficiency. Often data of this kind are so much the stock-in-trade of its possessors that they are loth to publish them. How much, then, shall a private library attempt to publish of what the concern has obtained as a business asset? The concern itself must settle that. There are those who say, "Get all you can and tell as little as you can." If therefore we tell everything, who is going to confide in us?

(5) Resistance of alloys. Data on this point were readily found in several books a little differently stated in each. Why not go to the same book as often as possible and in the future assume that this is the book responsible for the data which may be disputed.

The following questions came up more than once, sometimes however in a little different form. They emphasize the importance of keeping a copy of each bibliographical list that is made, lest there be a subsequent call for it; also the importance of better team work throughout the departments, so that if one man studies a special subject the fact will be known before others start to study it. (1) Copy of contract to build Panama Canal (Obtained once or twice before, but mislaid). (2) Air lift pumps for water (Wanted by two or more engineers at different times). (3) Auxiliary station uses (Seems to have been asked from the engineering and also the advertising standpoint). (4) Books on municipal ownership. (Demands for such literature would warrant some good bibliographical work). (5) Articles on depreciation (Requested by several specialists). (6) Motor cars on steam railroads (This and the two following show a series of kindred questions). (7) Gasolene car on Delaware & Hudson R. R. (8) Literature on gasolene cars, such as tried on Union Pacific.

The following requests were fulfilled in a variety of ways. In two or three cases some one happened to remember that somebody else knew the answer; in others a good guess was made at what the questioner intended, or luck in some form helped out. The human element enters into business of every kind, and we can hardly hope, in this generation at least, to solve all our questions by the luxury of a push-button or nickel-in-the-slot machine.

(1) References on electrical fountains. (2) Household refrigerating machine and electrically operated carpet-cleaner said to be advertised by Edison Co. of Boston. (3) Equation of hysteresis. (4) Article in Street Railway Journal a few months ago on "long-distance engineering" (i. e., "designing at arm's length"). (5) Volume of an engineering magazine (not American) that the petitioner had borrowed two months ago or so. (6) World's Fair official guide giving altitudes (i. e., World Almanac). (7) Bullinger's buyers' directory (i. e., "Hendricks' Commercial Register"). (8) Get me that sheet of paper which I said, "Look out or it will be lost." (9) Please file this paper in such a way that it can be found even if the one asking for it "don't know what they want."

Sources of Information.—The sources of information may be classed as follows: a, Documents, mostly typewritten, the records of the business. b, Books, pamphlets and periodicals. c, Maps, atlases, etc. d, Indexes, catalogues, lists, etc. e, Other departments. f, Other libraries. g, Business undertakings, institutions and people in general. h, Miscellany: some unappreciated publications, emergencies, and matters of that sort.

One naturally expects that books and periodicals are the chief sources of information in a business library as in any other, else the term "library" were a misnomer. And yet misnomer it may in fact be when applied to this library; for the printed literature was taken on several years after the document file had been established, and in numbers there are perhaps fifteen times as many documnts on file as books and periodicals combined. Hence more properly the Library is called the Filing Department of the office, where literature is kept that may be needed for the purposes of the business. (There is also a Mailing Department where the correspondence is kept.)

In round numbers there are some 2,500 books and periodicals and 35,000 documents, the collection being added to at the rate of perhaps 25 a day in the proportion of something like one to fifteen—not a large Library, but one that aims to be and ought to be efficient for its purposes. The library force of six persons may seem out of proportion to the number of pieces on file or the results obtained; yet we are asking for still another to help us out.

The document file need be considered but briefly. It is largely typewritten matter, including propositions, statistical and financial papers of various kinds, legal papers such as franchises, petitions, mortgages, contracts and the like, also reports estimates and a manifold variety of engineering papers all bound in such documentary fashion as convenience requires. Maps and photographs, though considered as belonging to the Document File, are often of such sizes and make-ups as to require their own cabinets.

Up to 1900 there were a few bound journals and a small but growing list of reference books, precariously looked after and borrowed with little regard to their ever getting back. In the course of two or three years it seemed wise to have a goodly collection of technical journals dating from the beginning of the century. Later on it was deemed a convenience to have at hand a set of duplicate indexes (also dating from the first of the century) to obviate taking from the shelves volume after volume of the heavy and often dusty books in the process of looking up some fussy little reference.

The Library subscribes for upwards of sixty periodicals, including such popular ones as the World's Work and such technical ones as the London Electrician; and for about forty newspapers local to the cities in which the company has business interests. The Library makes much use of indexes and aims to keep in touch with book reviews while in the Purchasing Department are a large number of trade catalogues.

The Library tries to have all the topographic maps that the Government has published, for who knows whence a proposition may come? It needs to know the nature of the country in considering an electric railway scheme; to know the course of rivers in considering water power electric transmission schemes. It would like to have to-day the topographic maps that were published yesterday; but how can we arrange this, since the Geological Survey is not allowed to open accounts? The present method is to send three dollars about twice a year for "all the maps that have been published since our previous order," (asking for the balance in sheets that are usually duplicates for us and often of mere waste paper value). In addition to these Government maps there are the Rand-McNally state and city maps, besides those of the Scarborough Company and of many other publishers for the different localities in which the company is interested; so also the Century Atlas and the yearly Rand-McNally Business Atlas, also some atlases local to Massachusetts. There is also the List of Maps of North America published by the Library of Congress, and when recently a map of the Arctic Ocean was wanted this publication was a suggestive source for reference.

The Engineering Index, of several volumes, from 1884 to the annual of 1906, inclusive, with also its monthly issue, makes a good starting point for engineering research. Not satisfied, however, with even the annual volume, the monthly issues are clipped and pasted in classified form, so as to have ready references as nearly to date as practicable. Another great convenience is a collection of duplicate indexes, which has proved a great time saver at little extra expense. Ten to fifteen cents is the usual cost of such indexes as we care to keep in duplicate, while several of them are incidental to our subscriptions to two or more of the journals that we refer to oftenest. An index to the more general periodicals, including also some of the important engineering and statistical monthlies and a few of the weeklies, is the Reader's Guide, most familiar to librarians. The very inefficient or careless indexing of some of our most important journals emphasizes the need for having at hand more than one source of reference. Frequently an article is found in one journal through a digest or abstract of it in another. Notably the convention papers of the engineering societies are found first through their abstracts in the trade journals whose indexes appear earlier and are of wider scope than those of the societies' transactions.

The office is decidedly departmental, the other departments being (alphabetically) the Accounting, Auditing, Corporation, Executive, Mailing, Securities, Statistical, Stenographic, Transfer, and Treasury. The managers in the field, the men sent out to take charge of interests in various parts of the country, and all who are under their control, should be included as having the Library directly or indirectly to assist them. By the way of indicating the size of the organization Mr. Lee quotes from the address of the chairman at the dinner recently held for the office members. He said: "I have made some calculations as to the extent of this Stone & Webster organization. There are about 350 men at present immediately connected with the organization as it is established here in Boston. That includes all the men here, the men of the Stone & Webster Engineering Corporation, the Managers and some others in the field. Now under the control and subject to the direction of these 350 men there are some 12,000 to 15,000 employees, or something over an army division usually placed under the leadership of a Major General."

The above signifies that here are not only many people for the Library to serve, but many from whom it may obtain facts, for whom, therefore, it should act more and more as the clearing-house of information. On request for a description of the Taylor Underfed Gravity Mechanical Stoker, the Library referred to the Purchasing Department for a trade catalogue. When asked as to the best books on gas it referred to the manager in charge of the Fall River Gas Works Company. To decide whether it is worth while to add this or that book to its files, the matter is frequently referred to such departments as have the subject of the book for their specialty. To obtain statistics, maps, etc., of the various cities in which Stone & Webster are interested, circular letters have from time to time been sent to managers in the different localities.

The Boston Public Library, the several libraries of the Massachusetts Institute of Technology, the State Library, the library of the Boston Society of Civil Engineers and a few other local libraries, have been helpful sources of reference. Of these the Boston Public Library is used far the oftenest, not only for emergencies, but habitually for looking up new books.

The Document Catalogue of Government publications, the encyclopedias in general, the Statesman's Year Book, the almanacs, the city directories, the pathfinders, the telephone books (of other cities especially) are among many sources of information that we fail fully to appreciate. Mr. Lee called particular attention to the telephone book as a convenient directory.

Mobilizing and specializing are, of course, important features of a business library. For instance, when the company began to consider sociological questions such as municipal ownership and the like, the Library was weak in the number of books of this kind. One of the potentates expressed himself in strong language regarding the Library's weakness on this point, and so a sweeping order was given which soon equipped it with all the books particularly wanted.

The filing is geographical as far as practicable, that is, the Library assigns the number 1100 to the State of Maine, 1110 to a tenth of it, 1111 to a tenth of that; 1200 to New Hampshire, 1210, 1211, etc., to its divisions, and so on throughout the country. The first figure to the right of the decimal is assigned to the company, the rest are for class divisions, 1 for estimates, 2 for statistics, 3 for legal matters, etc., with their subdivisions. Books defy geographical classification for the most part, so that they are shelved generally with numbers only to the right of the decimal. The decimal idea prevails in the Library, though not the Dewey system.

The items of the "Engineering Index" are clipped and pasted in sub-classified form, on convenient sheets for reference purposes. The classification was provisionally made four or five years ago by playing a long game of solitaire with the clippings of the monthly indexes of some two years and a half. With the progress of engineering new terms and ideas appear so that the classification needs continual revision. In the main this classification is a sub-dividing of the general divisions and sub-divisions as given in the Index, the asigning of the number 10 to civil engineering, 11 to bridges; 12 to construction, etc.; 20, etc., to electrical engineering; 30, etc., to mechanical engineering; 40, 50, etc., to other branches; and to the minor divisions, under bridges, 11.1 for arches, viaducts, trestles, etc.; and 11.11 for arched bridges and arches in general. So it is throughout the whole, the 60's and over being reserved for personal matters and sources of information that are not covered by the Engineering Index.

The "Stone & Webster Current Literature" is a private engineering index made from noting on slips, of card index size, articles of interest in the current periodicals, book accessions and various announcements and memoranda, and listing them on typewritten sheets—or printed ones as a recent innovation—with nearly the same classification as used for the Engineering Index. The items are selected as being of interest to the Stone & Webster organization, and, though distributed to a certain extent gratuitously, its usefulness to others is necessarily limited. This printed form is planned as a quarterly publication, but it lags too far behind for current purposes. Hence, in mimeograph form there is issued for office reference what are called Semi-Weekly Specials. These, of course, do not admit of the same refinement of classification as the less frequent ones, though the main general divi
sions are used and serve for convenience in ba
reference.

Of what worth in dollars and cents is the
brary to the organization? It is charged in
accounts as an expense, and some membe
the office regard it as a colossal expense.
in a while, however, just such persons ma
some question answered which enables
see that thereby plans in their work h
changed to effect the saving of thousan
lars, and for this reason there seem
been a healthy growth of the idea t

brary is a good thing and ought to be maintained in spite of all objections. Mr. Lee feels that when his department is more closely in touch with other libraries and getting information from various parts of the country to a much greater degree than heretofore, there will be decided evidence of what this department is, what it does, and what it can do for the benefit of the organization. It is too much in its infancy as a feature of business life to be accepted as a matter of course.

A Sewage Disposal Problem at Hanley, England.

The new sewage disposal works at Hanley must fulfil some unusually troublesome conditions. The engineers who designed them, Messrs. Willcox & Raikes, of London, were obliged to construct them on a very small site, within a short distance of numerous houses where any odor would cause serious annoyance. In designing the works it was necessary to provide treatment for dry weather sewage amounting to 1,800,000 gal., and wet weather sewage of 10,800,000 gal. In addition to making this provision for a wide range in capacity, the effluent must be discharged into a very small stream, which has a flow during the summer equal to but a small part of the volume of sewage reaching the disposal works. The sewage is first delivered into a screening chamber, from which it passes through three grit chambers having a total capacity of 410,000 gal., about a quarter of the dry weather flow. From the detritus tanks the sewage is discharged by gravity to low-level works or pumped to high-level works, any volume in excess of 10,800,000 gal. being allowed to pass into the river directly from the grit tanks, on the ground that it is too dilute to cause nuisance. The high-level works consist of four septic tanks of 2,460,000 gal. capacity, or 1⅓ times the dry weather flow, and 3¾ acres of bacteria beds. The low-level works consist of four septic tanks of 2,640,000 gal. capacity, and 5¼ acres of bacteria beds. These beds have walls of 14 in. of brick reinforced every 12 ft. by buttresses. They have concrete floors 6 in. thick with 6-in. semi-circular drains 6 ft. apart to carry off the effluent into a chamber where provision is made for allowing samples to be taken from the discharge of each ¼ acre. The filtering material consist of saggers, or refuse from the potteries in the vicinity. The beds are 4 ft. 9 in. thick and the material ranges in size from 2½ in. at the bottom to a top layer of particles from ¼ to ⅛-in. in maximum diameter.

The New Steel Plant at Gary, Ind., is to be developed immediately on an even greater scale than was originally contemplated, according to a statement issued last week by the United States Steel Corporation. The original appropriation to provide for the construction of the steel plant and the municipal works of the new industrial town adjacent to it was $75,000,000. The recently issued statement announces that an additional $45,000,000 has been set aside to be used in widening the scope and extent of the steel plant proper. Since the very extensive municipal works of the new town, which were described in The En- ineering Record for July 20, 1907, are practical- completed, and the vast amount of preliminary rk required to develop the site of the steel nt is well under way, the additional funds accordingly all be available for buildings and pment for the steel plant. When it is con- ed that in the neighborhood of $120,000,000 e expended at once in forming this nucleus new industrial center at the southern end Michigan, the magnitude which that cen- be expected to assume within the next is difficult to overestimate.

A Buttressed Concrete Dam.

The Beacon reservoir, a part of a gravity system of water supply, is situated just above West Point, N. Y., but on the opposite side of the river, on Mount Beacon, some 1,200 ft. above the high water level of the Hudson River, immediately back of the village of Matteawan, and was built for storing and furnishing a portion of the water supply for Matteawan, Fishkill-on-the-Hudson, the New York State Hospital at that place, and some important manufacturing establishments. A storage reservoir is of course calculated to equalize the run-off from the water-shed and the variations in the quantity of water flowing in the stream so as to produce so far as practicable, a sufficient supply the year through. The capacity of a storage reservoir, to be completely efficient when situated upon a moderate or small stream, should amount to the daily consumption multiplied by the probable number of summer and fall days during which the stream will be practically dry, or at least very much lower than the needed supply calls for; that is, during the hot months of August and September certainly, and perhaps during July and October as well, so as to provide against the actual use and wastage of water, besides the evaporation and whatever, if any, unavoidable leakages there may be from the reservoir itself and its conduits.

Also, the matter of spillway where the heavy rush of storm water is far above the ordinary flow of the stream needs careful attention, and, although the average rainfall per annum for the part of New York State under consideration is only about 48 in., it will be necessary for safety to provide spillway capacity for an impounding reservoir sufficient for the easy accommodation of the greatest quantity of water possible to reach such a spillway at any time; and this necessity was dramatically illustrated in a rather startling manner a few years ago at this very dam, when, in its form of construction previous to its present rebuilding and enlargement, the entire length of the dam was overtopped by a flood of storm water from an extremely heavy thunder shower, commonly called a cloud burst. In the reconstruction and increase in the height just finished, the new spillway was calculated for the heaviest known rainfall upon the water shed, was doubled in length, and was made about four times as deep as before, so that in all probability the area of watershed available, will be fully accommodated under the most extreme circumstances of storm water and run-off. From records kept since 1866 it is no doubt safe for supply to reckon upon 38 in. of water as the minimum rainfall for any year in this region, as 38 in. is the minimum for the period from 1866 to 1898, and very likely this amount will be greatly exceeded most of the time, and it will certainly be exceeded some of the time, as the average rainfall is 48 in. during the above-mentioned period for the Hudson Valley, from say, 10 miles south of West Point to 10 miles north of Newburg. The greatest rainfall for this period was 63.51 in. in 1888, the least rainfall was 38.33 in. in 1895; during 16 years of the 33, the annual rainfall was above the average, and during 17 of the years it was below the average. In 1869 and in 1891 it was very close to the average, just a trifle above; it was below 40 in. only two of the years, 1880 and 1895; and was below 44 in. during 8 of the years, 1872, 1873, 1874, 1875, 1876, 1880, 1883 and 1895.

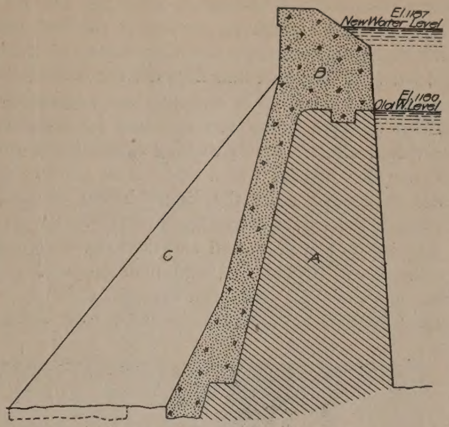
The watershed of the Beacon Reservoir, on account of its lofty situation, is of so moderate an area that there is a limit to the profitable dimensions of the dam, but from the short and rapid run-off, the rock nature of the watershed surface, etc., it is no doubt safe to calculate upon 65 per cent. of the rainfall as available for collection in the reservoir. The water falling as rain upon the surface of the reservoir to the amount of 100 per cent. would not quite cover the evaporation for the low year, and the low year with corrected evaperation will yield a storage of 103,000,000 gal. For the average year there will be a yield of 134,000,000 gal. from the shed, and about 2,000,000 gal. over and above the evaporation from the surface of the reservoir, making in all say 136,000,000 gal. of water available for an average year.

The above figures indicate that the original height of the dam, which was 23 ft. above the bed of the stream, was about 6 in. higher than was actually necessary for the lowest record of rainfall; was more than 4 ft. too low for the collection due to the average record of rainfall; and could be filled if 12 ft. higher than originally built, at the high record rainfall of 1888. There might be some slight variations from these figures, probably towards the high side, but they are according to the best-known methods for determining such facts. The original dam might have been built for the low record, if not built previously to 1888, for in that year the rainfall was nearly down to the lowest (shown in 1895) for the 33 years. The Beacon is a reserve supply calculated to fill between November and the following July, against the time when the other gravity supplies of this system fail in the summer months, and it must be considered that it is not necessarily emptied every year and therefore the dam could be higher than the figures actually indicate for a complete filling, especially as a wet season preceeding and succeeding a dry season would give a larger storage than the average, and with even two dry seasons successively, a very large storage at the start would be of great advantage. Considering all of the facts, it was deemed good judgment in concluding how much higher it would pay to build the dam for the accommodation of this rather limited watershed, to take advantage of the average rainfall in excess of 48 in. (48 in. being the average for 33 years) as a basis for calculation, and this was found to amount to 54 in. Then allowing for evaporation, it was determined that the dam could be raised 7 ft., giving a total storage of 186,000,000 gal., including the new slopes to be covered by the rise of the water level. Therefore the plans and specifications were prepared for an increase of 7 ft. above the original height of crest, and made of sufficient resisting power to permit of still further height being obtained, in case it was found that the run-off from this unusally rocky and impervious watershed proved to be of still greater percentage of the rainfall than had been allowed for.

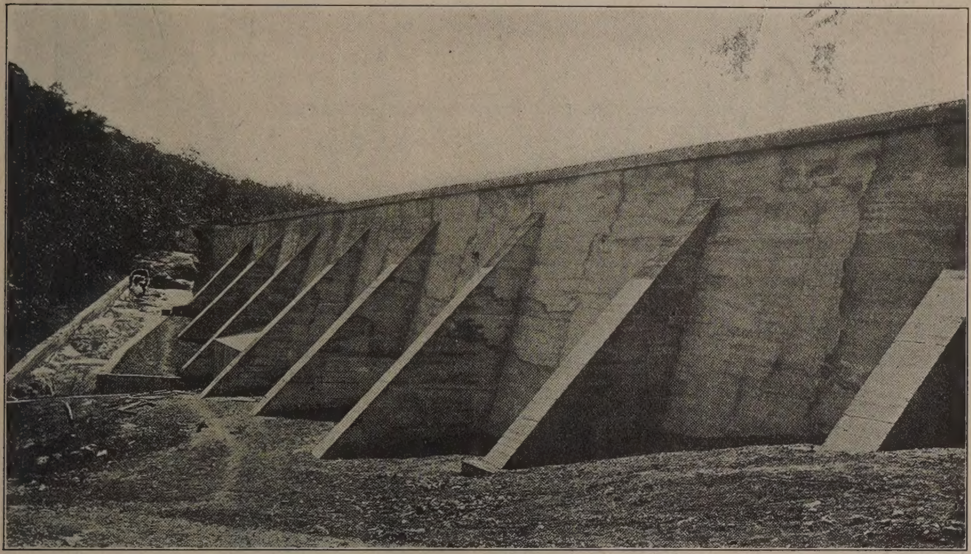
The accompanying diagram shows in the diagonal shading *A*, the typical or full section of the original dam, built of trap stone quarried near the site. The portion *B*, of the figure, indicating concrete, shows the addition to the dam in its fullest section, and also an outline *C*, of the buttresses. It will be noted that there is a groove or dovetail cut into the top surface of the original dam to provide a cut-off for the water and also to completely lock the old and new work together; also that the outer edge of the older dam is rounded to add strength to the concrete jacket at this point.

One of the views illustrates the method of putting up the forms for ramming the concrete in during construction, it being thought best to place all of the necessary forms at once, instead of ramming and shifting as is often done in concrete work; the complete series of forms permitting a continuous building of the work which was considered to give a better and closer knit character of fabric.

Another illustration gives a view of the enlarged and completed dam, showing the buttresses and spillway at the downstream face, and it will be noticed that the original dam is completely covered up and hidden by the buttressed reinforcement of concrete which now really forms the dam at the downstream side. The back of the original stone dam, or the side not here seen, still shows beneath the line of the new concrete work, but at some future day it will probably be sheathed either with concrete or new stonework, as this older work heretofore gave evidence of considerable leakage through the masonry, which although practically stopped by the front facing will be further improved by a new back lining.



Section of Enlarged Dam.



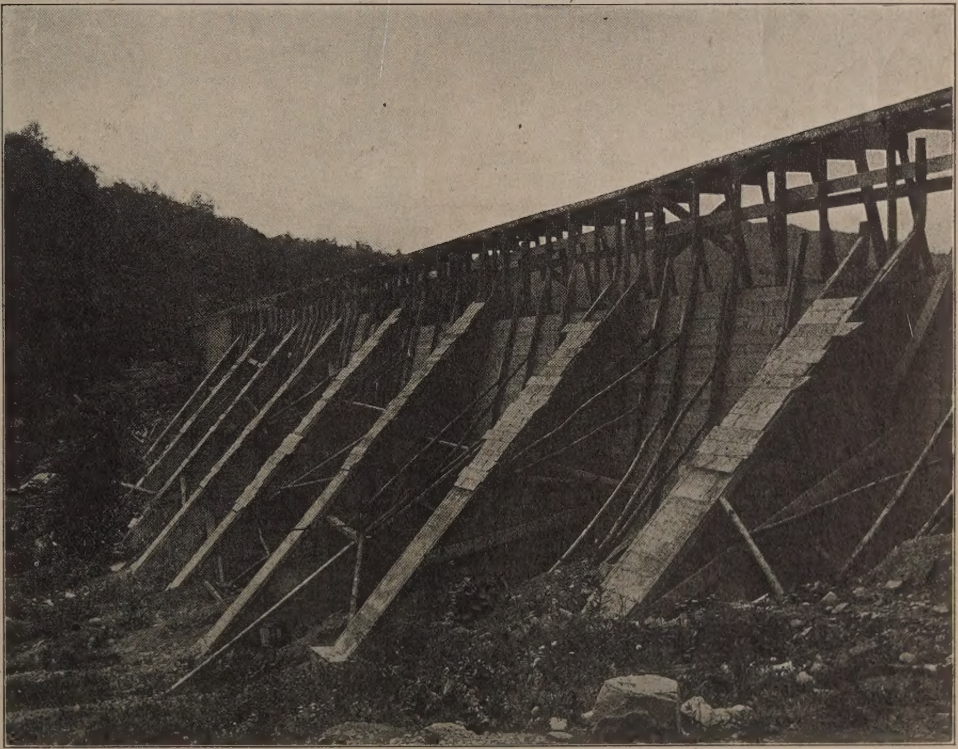
Completed Dam of the Beacon Reservoir, Matteawan, N. Y.

The original stone dam was built probably over twenty years ago, and was located upon a solid rock foundation bed, the rock extending well up the slopes at the ends of the dam, in fact to a sufficient height for the safe support of the new work. The original spillway was simply a shallow notch of very moderate length formed through the crest of the dam near the middle of the length, and permitted the outflow to fall from the top to the bottom of the dam at its greatest height of section. The spillway for the new work is of very liberal dimensions and is situated at the easterly end of the dam where the fall of the outcoming water is comparatively little and where a natural rock bed forms an excellent passageway for the storm water coming over the spillway, down to the stream bed below the dam.

The new concrete structure is about 350 ft. long and 33 ft. high at its greatest depth of section, the depth of the water immediately back of the dam being about 30 ft. The peculiar buttress design was suggested naturally enough by the extremely high cost of material delivered at such an out-of-the-way site; the prime object being to reduce the amount of materials to the lowest terms, the labor being quartered upon the premises reaching scarcely above normal. Materials such as cement, sand, crushed stone and lumber at the ordinary points of rail and water delivery were reasonable enough in price, but transportation to the site of the work was nothing less than heroic in character, and brought the costs of such materials up to the figures exhibited in the accompanying estimate.

ENGINEER'S ESTIMATE ON BEACON DAM REBUILT, AT MATTEAWAN, N. Y.

Quantity of concrete in place in completed work	1,500 cu. yd.
Concrete mixture—1 cement, 2½ sand, 5 crushed stone.	
Quantities of materials—	
Cement	2,400 bbl.
Sand	6,000 "
Crushed stone	12,000 "
Cost at the dam—	
Cement per bbl., bags	$1.85
Sand per cubic yard	4.50
Crushed stone per cubic yard	5.00
15,000 ft. B. M. lumber	450.00
Labor on lumber	600.00
Estimated cost of the dam—	
Crushed stone	$7,500.00
Sand	3,375.00
Cement	4,440.00
Labor	2,070.00
Forms for concrete	1,050.00
Foremen, expenses, etc.	1,065.00
Stone cutting	500.00
Valves and fittings in place	165.00
	$20,165.00
Contractors profit, expenses, etc., 10%	2,016.50
Total of estimate	$22,181.50



Forms for Buttresses and Addition to Dam in Place.

In round numbers, this is $23,000, and the contract was let for about 7 per cent. less.

This estimate was made in the spring of 1904 just after prices of all kinds of materials had begun to fall; they have gone considerably higher since that time, but even at present prices the above given cost would probably be safe. Considering the difficulties of transportation up a grade of 1,200 ft. within 2 miles, the contract price for the work was considered quite satisfactory, to the buyers at least; a part of the saving on the cost of the dam was probably due to the fact that the successful bidder calculated upon taking a stone crusher up to the work, which he did, and as the trap rock was obtained upon the premises without any cost to him, he also saved the cartage upon a good many tons of material, bearing only the small expense of operating the crusher.

The concrete improvements were designed, and the plans, specifications, and estimates were prepared by Mr. Charles A. Hague, Mem. Am. Soc. C. E., consulting engineer, New York.

A Stream Pollution Decision.

The pollution of streams by mining operators was recently before the Alabama Supreme Court in Ala. Con. Coal & Iron Co. v. Vines, 44 Sou. Rep. 377, when it was decided that, though mining companies may use a stream for mining purposes, they must not place in it anything which will materially pollute the water where it passes the land of a lower riparian owner, or which, being deposited on his land, by an overflow of the stream, will injure the land. The measure of damages due to coal dust deposited by such an overflow includes loss of crops already sustained, as well as permanent injury to the land, though the loss of crops cannot be added to permanent damages as such.

Economical Methods of Highway Bridge Construction.

The constantly advancing prices for all kinds of timber have made the cost of falsework expensive for light bridge erection, and serious study has been given to different methods for reducing it. A novel and ingenious scheme for making wooden falsework adjustable to different heights and adapting it to be used over and over again for successive bridges, so that it is shipped from place to place like hoisting engines or other parts of the bride erector's appliances, has recently been developed and satisfactorily used by the York Bridge Co., of York, Pa., Mr. Guy Webster, President, and Mr. F. W. Bigger, engineer.

For ordinary work transverse bents are made with two vertical and two battered posts 10x10 or 12x12 in. The timber for these is purchased in as long lengths as are available and the joints between successive stories at each end of the transverse horizontal struts, corresponding to the caps and sills of ordinary construction, are made with a pair of steel plates about 18 in. wide and 5 ft. long in vertical planes with their long dimension horizontal. Vertical 12-in. channels 18 in. long are riveted across one side of each plate with clear spaces of 1 in. between them, and the 1-in. spaces are punched for ⅞-in. horizontal tie bolts connecting the pairs of plates on opposite sides of the horizontal struts and of the vertical posts.

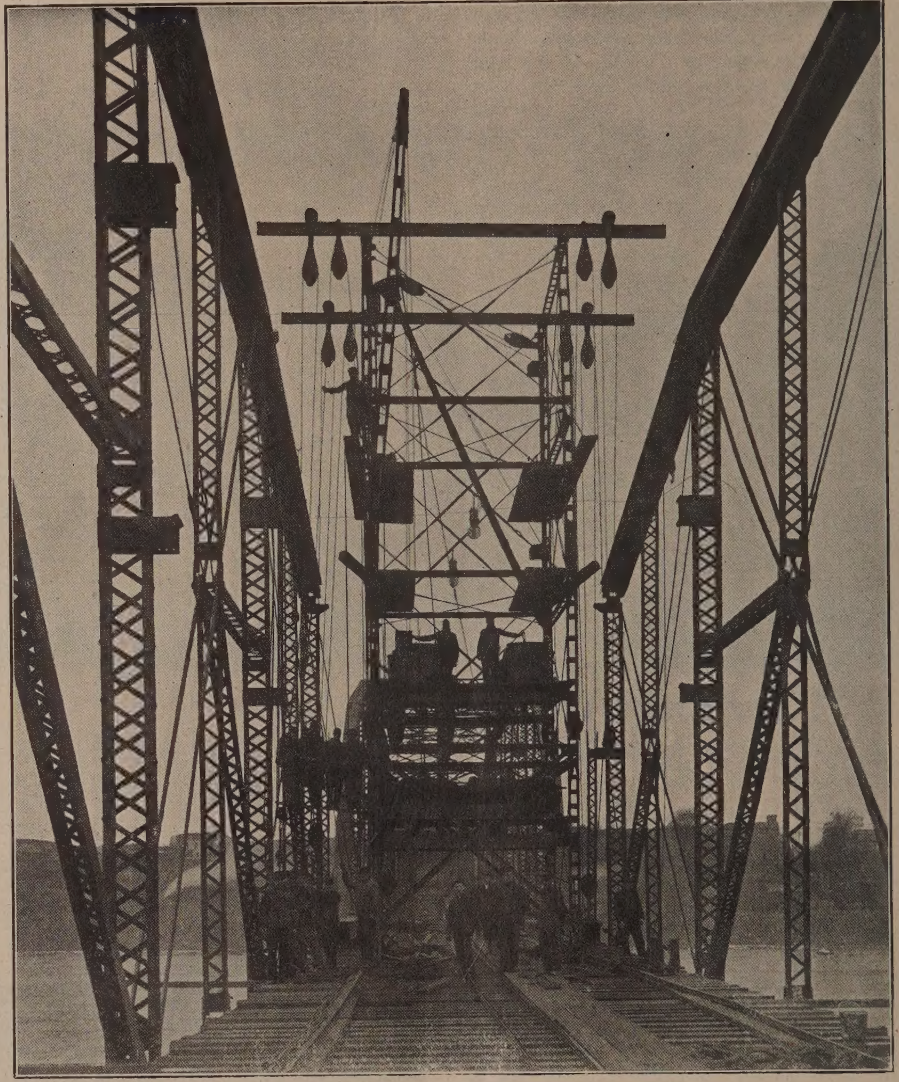
The vertical and battered posts and horizontal struts are arranged side by side between the inner faces of the plates and the latter are clamped very tightly together by bolts passed through them in the spaces between the timber. These can be drawn up tight enough to develop friction sufficient to hold the entire load on the falsework and thus enable the connection to be made absolutely without cutting or boring the timber and provides for it to be made at any point of the vertical posts, thus enabling the latter to slip past each other and make a telescopic joint which permits of any height of falsework within the limits of the length of the material. The plates have slotted holes to receive the hook ends of diagonal rods with sleeve nut adjustments and with sections made with pin-connected flat bars enabling the lengths of the diagonals to be varied by increments of 3 in. in the pin holes and of smaller distances by the sleeve nut adjustments. Falsework assembled with these connections has been found very rigid and satisfactory and has been taken down and moved from one site to another with greater economy and convenience.

An important advantage of this type of falsework is the opportunity it affords of compensation for any irregularity of settlement in the different posts. If one of them goes down farther than the rest, or if irregular scour exists underneath it, it is very easy to loosen the clamp bolts adjacent to it, insert a jack on top of it with reaction pieces reaching up to the next joint, and force it down readily as far and as often as may be required without interfering with any other part of the falsework. The adjustable diagonals also lend themselves very satisfactorily to the distortion of panels and can be changed as often as the falsework may require it to provide for settlement or any other variation in the panel.

This falsework is erected by a special traveler with a horizontal rolling platform and two stiff-leg derricks mounted on the forward corners with sufficient reach to overhang one panel in advance, and sufficient strength to lift together a completed bent of falsework, and put it in position. The steel work is erected by a second 2-bent traveler running inside the trusses and provided with four booms, one at each corner. The bents have no bottom transverse sills, but are connected by longitudinal top and bottom sills and X-bracing. Their transverse X-bracing is arranged so as to give clearance enough in the center for material cars to be run through the traveler on a track laid between its posts, and thus deliver directly to the forward booms. The hoisting and topping-lift tackles of each boom are operated by separate individual electric hoists making altogether 8 for the traveler, besides which there is an additional hoist suspended from the jigger beams at each corner of the traveler, making a total of 12.

The hoists are of special construction, designed by the York Bridge Co., and manufactured for them by the Westinghouse Electric Co. They consist essentially of a small drum with spiral grooves to guide the steel cables used. They have pinions integral with them which engage a worm thread cut on the shaft directly connected to the motor, the latter being made special for the purpose and adapted to instant reversal. This arrangement keeps the load always under absolute direct control with no possibility of back-slide or overhauling, allows the motor to be started and stopped at any point or to be reversed instantly and dispenses with the use of brakes, friction clutches, and other complicated parts of an ordinary hoisting engine. They are so simple that they require little or no attention, and do not suffer when exposed to severe conditions and inclemencies of very bad weather. The same hoists are used on the derricks of the falsework traveler and for all other hoistng purposes in the erection work done by this company.

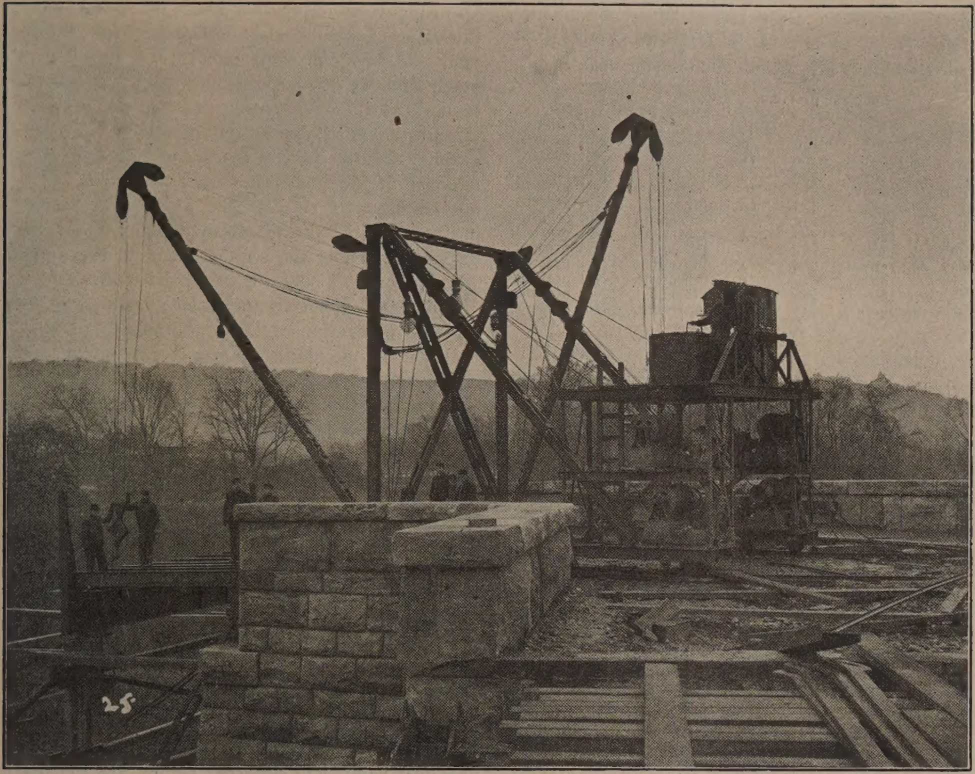
The erection appliance considered standard for bridges of any magnitude includes a boiler plant shipped direct to the site and installed in a special power house built for the purpose at any convenient location on shore near the bridge site. An air compressor driven directly by steam is also installed there and a Westinghouse generator of 35 k.w. capacity furnishes the electricity for operating all of the hoists and makes the plant entirely independent of local electrical power. Riveting, reaming, and steel drilling are done by tools built by the Cleveland Pneumatic Tool Co., and facilities are thus provided for handling highway bridge erection as rapidly, economically and thoroughly as is customary with railroad work. A recent bridge erected with this plant is the State Bridge at Berwick, Pa., and another, now in course of erection, is a fourteen-span bridge at Sunbury, Pa.


Steel Inside Traveler with Twelve Hoists.

The Berwick bridge, across the Susquehana River, is 1,800 ft. long and carries a highway at an elevation of about 60 ft. above the water and on a 1½ per cent. grade. It comprises six 250-ft. channel spans and three 100-ft. approach spans with a roadway 22 ft. in the clear carried on transverse wooden joists, and contains about 3,000,000 lb. of steel and 270,000 ft. b. m. of lumber.

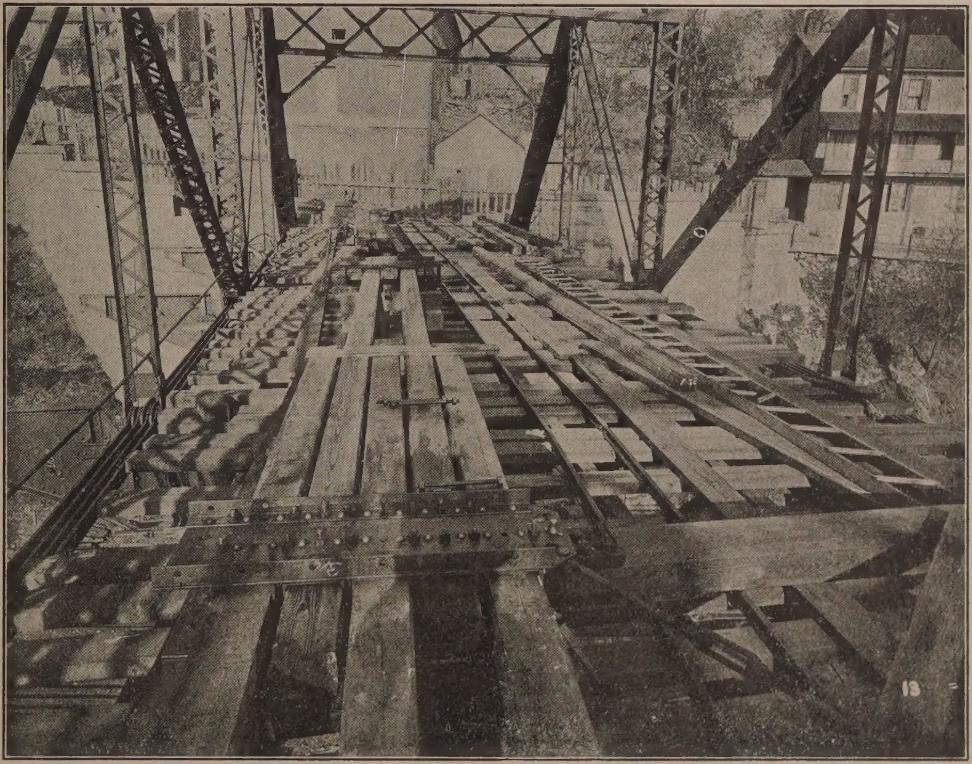
The very irregular river bottom is of shale rock with vertical seams filled with gravel and coal culm which washes in and out with varying stages of the water. A survey and careful soundings were made for each of two lines parallel with the bridge axis and 10 ft. distant from it in the planes of the falsework vertical posts. From these data profiles and cross sections were prepared and the falsework was accurately designed to suit the location. All posts were made with

8x8-in. timber with the corners slightly chamfered to fit the fillets of 8-in. channels riveted to the insides of the clamp splice plates previously described. The posts were assembled with struts and diagonals complete in horizontal planes near the traveler track. They were run through the traveler on trucks and lifted and swung forward one panel in advance by the traveler booms which maintained them in a vertical position until their lower sections were driven to solid bearing by a hammer (consisting of a 6-ft. section of old rail or equivalent weight), operated by a whip line from the hoisting engine and guided by a man standing on the joint. The braces and diagonals were connected making the bent stable, stringers and track laid and the traveler advanced to the next panel and so on. In each bent the center transverse strut was pin-connected to the splice plates on the first post and at the other end was temporarily lashed to the top of the post. The lower strut was similarly connected to the other post, so that when both posts were in position it only remained to add the top strut and longitudinal braces.



Traveler Erecting Falsework.

Electric Hoist.



Part of Falsework Bent Assembled Ready for Erection.

The falsework traveler was made of steel with clearance through it for material cars and had two-story rear extension platforms on both sides for the four electric hoists which operated the booms and were all controlled by one man on the bridge platform overhead, where he could see all parts of the work. The falsework posts were lifted and swung out by both booms together, after which one tackle was slacked off faster than the other to drop the foot. This traveler was also used to erect the low trusses of the approach spans.

Material was unloaded from the cars by an 80-ft. guyed steel derrick, which arranged it in assorted piles and loaded it without unnecessary handling on the service cars which delivered it to the erection traveler. This traveler, also of steel, is about 60 ft. high, weighs 20 tons, and has four wheels. It is of adjustable width and in this case was framed with a width of 16 ft., leaving 3 ft. clearance on both sides with the trusses. Small working platforms on both sides are adjustable to any heights convenient for making the truss connections, and the twelve electric hoists are all controlled by one man on the upper platform. The traveler was provided with arc lights run from the dynamo in the power house at the end of the bridge, and used early in the morning and late at night of short dark days. Before the trusses were assembled by the main traveler the floorbeams and joists were set by the falsework traveler, great care being taken to place them very accurately, for which purpose they were adjusted to line and level by an instrument set up on the pier masonry. After the trusses were swung the falsework bents were removed by tackles suspended from the superstructure; their removal and transfer from one span to the next proved to be a difficult and expensive task.

The erection of this bridge was described and illustrated in an interesting and valuable address made by Mr. Webster at the annual meeting of the Bridge and Structural Society at Chicago, Jan. 15 and 16, 1907. He spoke from a practical and commercial standpoint and strongly urged the importance of careful investigation and study, thorough preparation and the best and strongest appliances for erection work. He criticized the tendency to dispense with permanent erection organization and asserted that a good erection is the best salesman. Careful examination of all conditions, analysis of the requirements and provision in advance for all successive stages and operations of the work are essential to satisfactory work, and it is economcal to make new appliances of ample size and strength. He emphasized the superiority of a poor idea well planned over a better idea with no preliminary thought, and advised a system of accounts classifying the costs of different items of the work. He suggested improvements in removing and transferring falsework and in a light traveler that should be adjustable to pass under transverse struts, for painting, riveting, etc., at any height.

The Pig Iron Output of this country during the first half of the current year was 13,478,000 gross tons, the largest production during six months in the history of the American industry, and greater than any year before 1899

A Submerged Power Station.

A submerged power station that rivals in interest, although much smaller, the famous plant constructed at Snoqualmie Falls a few years ago has recently been put in operation on the Patapsco River, near Ilchester, about 15 miles from Baltimore. It is the first example of a type of power station which the designers, the Ambursen Hydraulic Construction Co., of Boston, and Mr. H. Von Schon, of Detroit, consulting hydraulic engineer, have suggested for a number of places. In reinforced concrete dams of this type, there is a large space within the structure, and the desirability of utilizing this space for power machinery is evident in those cases where other local conditions do not permit a greater head to be developed by constructing the station elsewhere.

The cross-section of the dam near Ilchester is shown in the accompanying cut, which also indicates the position of the water wheels. The dam is 220 ft. long and 26½ ft. high from normal tail water to the overflow of the spillway, which is 168 ft. long. At each end of the spillway the buttresses and deck are carried 10 ft. above its crest, making a total height of 36½ ft. at these places. The buttresses supporting the deck are 12 ft. apart on centers, 2 ft. thick at the bottom and 16 in. thick at the top. The deck is 18 in. thick at the bottom and 10 in. at the top and reinforced with corrugated bars in the usual manner adopted by the builders.

The apron extends only half way down from the crest, the remaining downstream portion being entirely open and provided with windows so that the interior may be lighted. The shape of the apron is such that the water is thrown away from the windows, and, on a clear day the illumination is all that could be desired, although it is poor during rainy weather and at times when the water is muddy.

The water-tightness of such a station has to receive special care, because electrical apparatus will not give the best service in the presence of considerable moisture. Up to the present time no trouble whatever has been experienced from dampness at this plant. The concrete of the deck is a 1:2:4 Portland cement mixture laid very wet, but without any particular precaution to insure tightness. Nevertheless, very little water finds its way through the concrete, and that little trickles down the under surface of the deck to a drain at the bottom. In order to make it certain that no water falls on the equipment of the station, 108 ft. of the dam which houses the power plant is fitted with a false ceiling, as shown in the cross section. This completely protects the apparatus.

The station contains two 34-in. horizontal Leffel wheels with Woodward governors, each wheel direct-connected to a 300-kw., 11,000-volt, three-phase, 60-cycle alternator. Each alternator drives by a belt a 125-volt exciter. The water for the wheels is taken from the deck of the spillway about 5½ ft. below its crest, through a 7-ft. flume, which runs directly into the shell of the wheel. It is discharged from the latter through a draft tube carried down into a well about 3 ft. below the river bed, from which it flows away through a channel cut in the rock. The advantage of such an arrangement in eliminating losses due to long pipes and bends is manifest.

The plant is owned by the Patapsco Electric & Mfg. Co., Ellicott City, Md., and supplies current for lighting and power purposes.

PERMANENT BENCH MARKS established by the City of Chicago in 1898 have settled in the district honeycombed by the operations of the Illinois Tunnel Co., but not elsewhere.

Letters to the Editor.

RESULTS AT THE SOUTH BETHLEHEM, PA., FILTER PLANT.

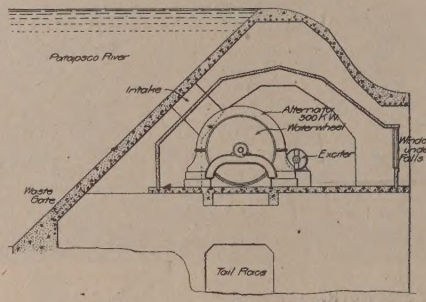
Sir.—The following are the results of the bacterial analyses of the water furnished by the Bethlehem City Water Co. to its consumers, as per reports submitted by Mr. F. W. Green, bacteriologist of the East Jersey Water Co., Little Falls, N. J., to Dr. H. S. Drinker, president of Lehigh University, South Bethlehem, Pa.

Date.	Bacteria in 1 c.c.		Colon Bacilli in 1 c.c.	
	Subsidence Reservoir.	Filter Outlet.	Subsidence Reservoir.	Filter Outlet.
Dec. 29, 1906..	100	2	Present.	Not present.
Jan. 14, 1907..	2300	11	Present.	Not present.
Feb. 16, 1907..	130	5	Present.	Not present.
Mar. 9, 1907..	210	3	Present.	Not present.
Mar. 23, 1907..	475	12	Not present.	Not present.
Apr. 6, 1907..	350		Not present.	Not present.
May 11, 1907..	1700	3	Not present.	Not present.
Apr. 20, 1907..	150		Present	Not present.
May 25, 1907..	900	2	Present	Not present.
June 8, 1907..	950	1	Not present.	Not present.
June 22, 1907..	550	1	Present	Not present.
July 13, 1907..	950	0	Not present.	Not present.

Yours truly,

Philadelphia, Pa. A. W. K.

[The South Bethlehem slow-sand filter plant was described in detail in The Engineering Record of July 15, 1905. It was designed by Mr. P. A. Maignen and has an ultimate capacity of 4,000,000 gal. per day at a uniform rate of about 7,000,000 gal per acre per day. The settled water is passed through preliminary scrubbers before it is delivered to the slow-sand filters.]



A Submerged Power Plant.

THE TOPOGRAPHICAL PARTY.

Sir—I have noticed that the most disputed topics in a railroad preliminary camp in mountainous country are the proper organization and the methods of the topographical party. The reason is largely because many of the men were educated on prairie work and try to introduce the methods to which they are accustomed.

Many of the older railroad surveying manuals and field books give a somewhat elaborate organization for the topographical party, and prescribe the duties of topographer, assistant topographer, rodman and tapeman. Most field engineers have concluded that such an organization is not economical and on many roads, where hand level and tape are used, the party consists of two men. While it is true in general in open flat or gently rolling country that the four-man party is unnecessary, it may not always be true in mountain districts. Where there is little sketching to be done, a topographer and a rodman can do fairly well in open country where there are few buildings, and contours are taken for only a short distance each side of the center line. But, on the contrary, where much sketching must be done the opening of the note book and fumbling for a pencil every few feet is costly in time, and tends toward slovenly note keeping, while the amount of detail work required of the topographer introduces a considerable liability to error.

But not satisfied with using the two-man party in its proper field, level country, the prairie-educated engineer when transferred to the mountains often fails to recognize the new conditions and sticks to his pet organization, arguing that it saves in the total number of men on the work. He does not recognize that the vital points are the cost of the survey per mile, and the reliability of the data, and on these bases the three or four-man party demands consideration. I have seen mountain preliminary parties laid up one or two days every week in order that the transitman and the levelman might help the topographer catch up in his work. Many engineers fail to recognize the value of specialization and expect the transitman and levelman and their crews to take as much and as good topography in a day as the topographical party. In few cases is this realized. Of all the positions in the field, that of topographer requires more experience and the greater exercise of judgment than any save that of locating engineer or chief. This practice of "catching up" has the further disadvantage of breeding discontent among the cheaper men on the party, who, as a rule, dislike topographical work.

From the writer's experience a return to the larger organization of the topographer's party is desirable in mountain country for economy and improvement in the quality of the work. The topographer should be given at least three men, and where the mountains are steep and the brush thick, four men, the last man carrying an ax and acting as rear tapeman when there is no cutting to do.

Any man of ordinary intelligence can be taught to use a hand level with accuracy and a $50-per-month man once given the height at the center line above or below the contour can pick out the succeeding contours with more reliability than the topographer himself, since his sole duty is to carry his elevations, while the topographer must sketch, note the character of the land, and record all the data. A 5-ft. stick, on which to rest the hand level, and a 7 or 8-ft. rod, with the alternate feet painted in different colors, are the best "instruments" in mountainous country.

The rodman in going uphill acts as head tapeman and the topographer, levelman or extra man, when one is provided, reads the tape. Going downhill the levelman drags the tape, and one of the other men reads it. The most rapid work can, of course, be done with two tapemen and a hand levelman, in which case the topographer does nothing but handle his note book. But even with three men the topography in quite hilly country can be kept up pretty well. This saves laying off both transit and level parties, a costly procedure, and requires only one or two extra men, depending on whether three or four men are used in taking topography, at the lowest salary paid, the regular topographer's rodman acting as hand levelman. I have heard it objected that a rodman is not paid to bear the responsibility of a levelman, but the average rodman is able and anxious to do the work.

The improved quality of the work can be judged when it is considered that under the two-man method the topographer acts as levelman and carries his elevations in mind, reads the tape and carries distances metally, records all data, sketches, and makes necessary topographical notes, while with three or four men his duties are confined to sketching and recording.

Very truly yours,

TRANSITMAN.

Missoula, Mont.

CONDENSER TROUBLES in a station having two surface condensers employing sea water for cooling have been overcome by placing pencils of zinc about 6 in. long in the suction chamber. Formerly the galvanic action between the iron base and the other metals in the condensers led to the rapid corrosion of the iron. This has apparently ceased entirely since the zinc pencils were introduced, although the latter are eaten away rapidly.